OLUME 52 NUMBER 4 . . . ONE YEAR FOUR DOLLARS

GENERAL ELECTRIC
Review

Illinois U Library

TABLE OF
CONTENTS
Page Three

April, 1949

The search is ended *Permanent Flexibility* TURBO

In his search for the fountain of perpetual youth, Ponce de Leon would have found a perfect analogy in the improved Turbo Varnished Sleeving in which there is inherent, in its flexibility constituted insulating varnish, the antidote to hardening of the arteries.

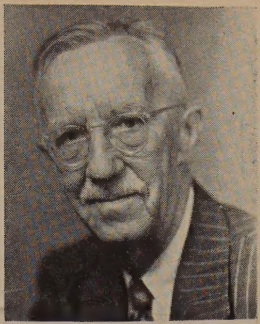
Besides this great step of advance in the varnishing process of cotton sleeving, there are insured in this Turbo Varnish Impregnant topmost electrical insulating requisites—stabilized increased dielectric values, greater resistance to elevated temperatures, practical resistance to the effects of soldering-iron operations, acids, oils, alkalies, and electro-chemical influences.

Non-cracking, non-chipping, non-peeling regardless of angle of bend or twist. A knock-out to commonly encountered insulation failures accruing from embrittlement resulting due to the effects of aging.

Thermoplastic Insulated Wire;
Thermoplastic Insulated Sleeving;
Mica, block, films; Mica-Plate, segments. Markers; Wire

WILLIAM BRAND & COMPANY
276 FOURTH AVENUE, NEW YORK 10, N. Y.—325 W. HURON STREET, CHICAGO 10, ILL.

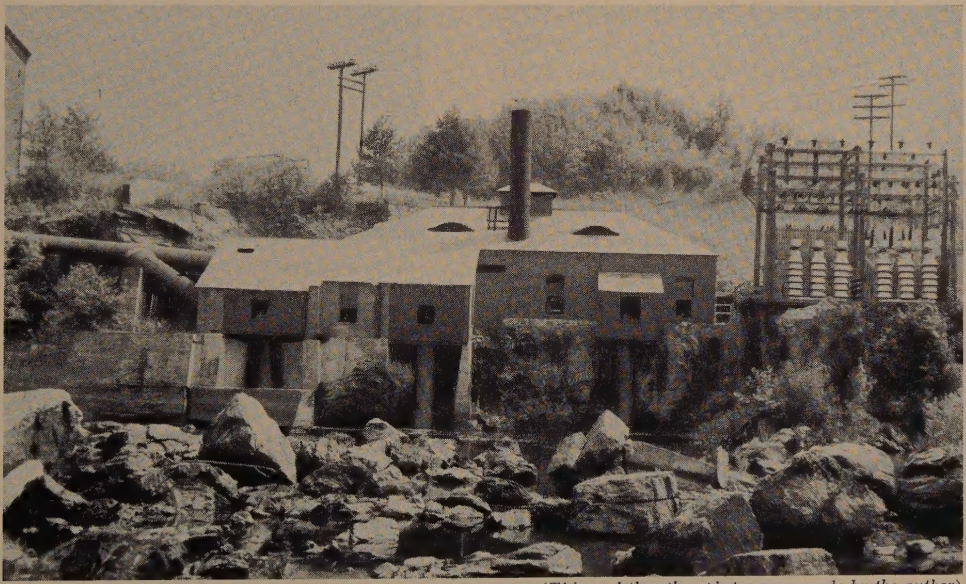
AN OLD HYDROELECTRIC PLANT VITH GENERATORS AS ACTIVE AS EVER AFTER HALF A CENTURY OF SERVICE



By A. PALME
Power Transformer Engineering Division, Pittsfield Works
General Electric Company

A HYDROELECTRIC station near Greenwich (N. Y.) may lay claim to being the oldest power ouse now operating with the same machinery for half century.

At that place on the Battenkill, a 50-ft-high natural aterfall had attracted the attention of an early Dutch ttler, one Garritt Lansing, and in 1800 he established waterwheel-driven grist mill at the site. A saw mill id a pulp mill were added later and other water rights ere leased to his successors, so that by the year 1891 a nall industrial center had been established in the wnship.



(This and the other photos were made by the author)

The old hydroelectric plant located at Greenwich (N.Y.) as viewed from the tailrace side. Note the draft tubes under each waterwheel

In that year of 1891, Gardner and Rich belted a -hp direct-current dynamo (a Ball machine) to one the several waterwheels, and electric lights in the rm of arc lights came to the main street and into me stores of Greenwich village. A flat rate was estabshed to pay for the lights, and the dynamo was run om dusk to dawn. A company under the name of onsolidated Electric Co. of Greenwich, with Dr. enry Gray as president and I. V. Gill as superintendent, was formed and operated this plant successfully, supplying 125-volt d-c service to Greenwich and nearby Schuylerville.

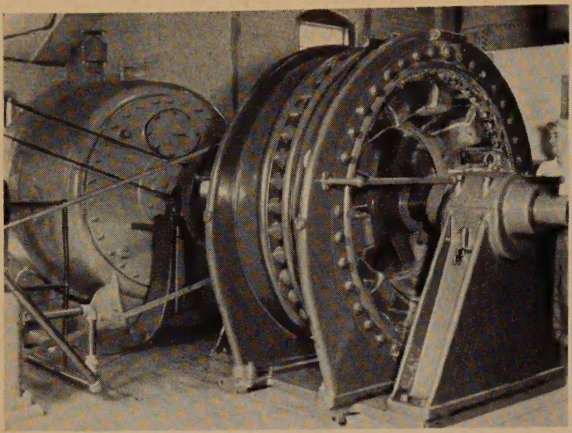
About ten years later (1900) the old wooden dam above the plant was replaced by a concrete dam, the d-c dynamo was retired, and negotiations were made with the Stanley-Kelly-Chesney Works* at Pittsfield (Mass.), commonly known as the "SKC," to install two (and later a third) 350-kw two-phase generators, direct connected to horizontal-shaft water turbines made by the Hunt Co. of Orange (Mass.). Chief engineer Cummings C. Chesney (the "C" in SKC) and John Kelly (the "K" in SKC) came personally to Greenwich to sell the generators and to supervise the installation of these machines which were designed by William Stanley (the "S" in SKC). The generators provided 2200 volts at 60 cycles, and are the same machines that are still in daily operation.

To furnish power also to Cambridge—nine miles away—a bank of three oil-insulated transformers was installed in 1906. These stepped the generated voltage up to 4600 volts three-phase. At Cambridge, a similar bank transformed the power back to low-voltage two-phase. All of these were SKC transformers, designed

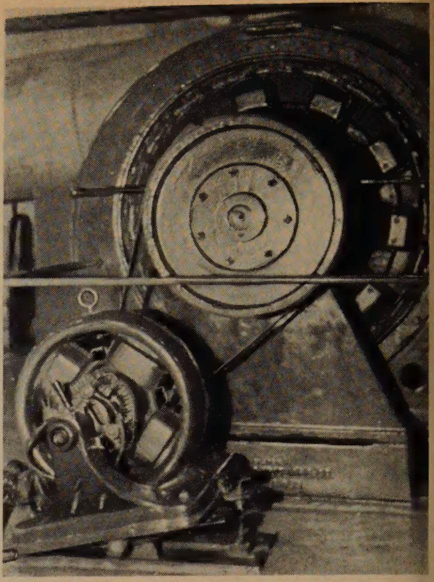
---

*Now the Pittsfield Works of the General Electric Co.

This article is so paged that without mutilating other articles, it can be adily removed for filing as a group of full-size consecutive pages.—Editor



The plant's No. 1 generator, a 350-kw 2200-volt two-phase SKC machine installed in 1900. Hunt waterwheel is shown directly behind



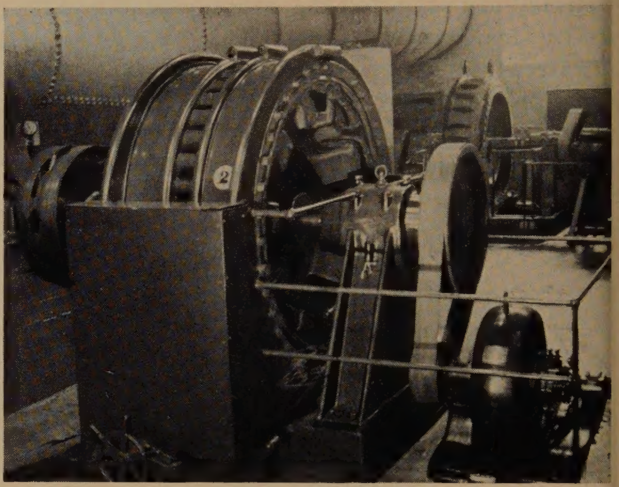
The No. 2 generator, a duplicate of the No. 1 machine and installed at the same time. Note the hinged mounting of the d-c exciter to keep its driving belt tight

by Stanley and built at the old Stanley Plant in Pittsfield.

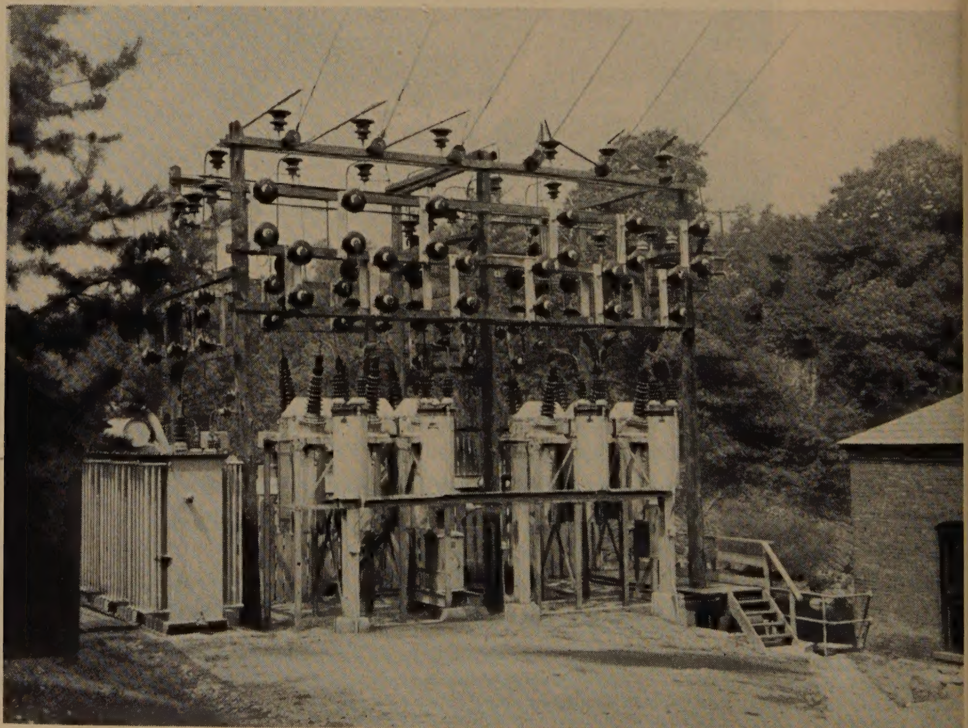
One ½-hp a-c motor was installed in 1898, and a 2-hp motor for an ice-cream plant was connected to the system in 1902. At that time, 298 customers were supplied, and the annual gross revenue was $18,000. The station was then operating day and night, and watthour meters were introduced.

In 1924 the plant was sold to the Adirondack Power & Light Corp. which was later affiliated with the New York Power & Light Corp. In 1927 a 33-kv loop tie line with necessary transformers was installed, connecting this plant with 60-cycle generators at the hydro-station at Spier Falls; at which time there were 2700 customers, served by 13 miles of transmission and 27 miles of distribution lines, and the annual revenue was $120,000.

Re-babbitting of the main bearings was the only repair to the three old generators since their original installation.

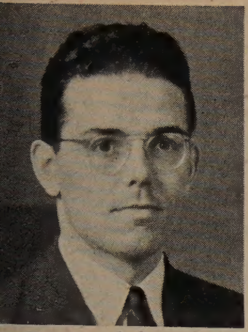


In the background is the No. 3 SKC generator of the same rating as the other two units but installed in 1902



The transformers and switchgear that were installed in 1927 for the 33-kv tie line to the Spier Falls plant

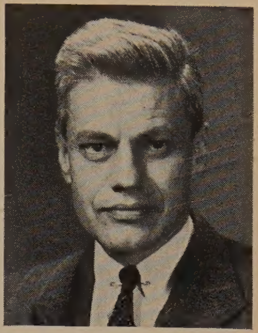
SELECTING ELECTRIC DRIVES FOR LOOMS



Robert J Demartini

A method for calculating requirements of drives for looms from knowledge of system constants eliminates extensive testing. Pulsating character of load is a factor in selecting instruments and interpreting test data. Value of inertia in the successful drive

By R. J. DEMARTINI and A. F. LUKENS
Paper & Textile Division
Industrial Engineering Divisions
Application Engineer
Lynn Induction Motor Section
General Electric Company



A. F. Lukens

BECAUSE the load imposed on motors applied to conventional weaving looms is so complex, includ-ng many components o differing characteristics, roper application of such motors has required special kills and laborious techniques. Recently, a program of nalytical testing directed at developing a simple, traightforward method for selecting loom drives was ompleted. A new line of loom motors was developed, nd the methods presented in this article played a promi-ent part in the formulation of final specifications. This rticle has been prepared for the purpose of presenting summary of the fundamentals and a study of the asic mathematical relations evolved.

HE PROBLEM

What is desired is a method whereby, given basic hysical constants of a loom, it will be possible to etermine the characteristics of the proper drive for it. f the mechanical motions in loom operation can be educed to a few basic mathematical relations built round values of the loom constants, the job to be erformed by the drive may be clearly defined. With hese mathematical tools at hand, the task of selecting he proper motor should be exceedingly simplified. This s precisely the approach described in this article.

Ultimately, the drive chosen must conform to the fol-wing functional specifications:

(1). The drive must have sufficient torque ability to operate the loom even under the extreme conditions exemplified by the high-load break-in period and by those installations where supply voltage may be low.

(2). Operation of the drive must be such as to impart the proper "feel" to the loom—a characteristic so important to the trained loom-fixer, and one to be evaluated by him. The amount of speed variation pick-to-pick (flights of the shuttle) and the character and magnitude of loom vibration are factors which determine the feel. This factor has not yet been reduced to quantitative values.

(3). The drive must operate on the loom load without overheating.

THE LOOM

Weaving, the process of interlacing two systems of filaments arranged in right-angle relation, is done on a machine known as a loom. In its earliest form, shown in FIG. 1, it consisted of any convenient horizontal beam from which the warp or lengthwise yarns were hung, a bobbin carrying the "weft" (filling or cross-wise yarn), and a flat wand whose function was to separate the warp strands so that the bobbin might pass between them and to beat the weft into place after each insertion. Stones were often hung as weights at their lower extremities to maintain tension in the warp yarns during the weaving operation.

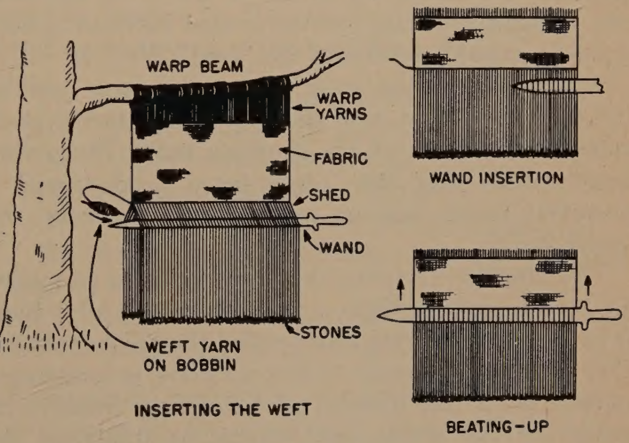


Fig. 1. The art of primitive weaving is depicted by this sketch showing an early loom and component parts of the basic operations

To obtain a plain one-up, one-down weave, alternate yarns were moved forward by partial rotation of the wand. The bobbin was handed across from right to left in the "shed" thus formed, and the filling yarn thus laid in position was beaten into the fabric. The wand was then withdrawn and reinserted between the ends, this time with the warp yarns which previously lay on the rear side brought forward and those in front dropped to the rear. Again the bobbin was passed through the shed from left to right, and the wand used to beat it up into the woven section. This process was repeated over and over to produce a web or fabric.

This article is so paged that without mutilating other articles, it can be adily removed for filing as a group of full-size consecutive pages.—EDITOR

Presented as a paper at the AIEE Winter General Meeting in New York City, Jan. 31 to Feb. 4, 1949.

In FIGS. 2 and 3 are shown the elements of a modern power loom, and in FIG. 3A a photograph of the motor end of a modern loom is shown. The same basic functions as practiced in primitive weaving are incorporated in this automatic machine. Warp yarns, which here may number 10,000 to 15,000 or more, are many hundreds or thousands of yards long and are wound parallel on a large spool, called a "beam." (This term has been carried over from the early loom construction.) This is placed at the rear of the machine, its center-shaft set in bearings to permit rotation as the warp ends are paid off. All of those ends are led up over the guide-roll (whip-roll), divided into two equal-numbered systems, and laid over and under the "lease rods." The principal function of lease rods is to separate the closely spaced ends so that the weaver can more easily trace individual ends when tying broken ones. From here, each yarn is fed through its own "heddle," a steel wire with an eye through which the yarn passes in the harness frame.

The raising and lowering of the harnesses, and thus the warp yarns, positions those yarns above and below each weft thread in the order required to obtain the pattern desired in the finished fabric. In FIG. 2 there are just two harnesses shown—the requirement for producing a plain one-up and one-down weave. With each pick, one harness is raised and the other lowered. From each harness, the two yarn systems converge to enter the fabric, forming a shed. Between the harnesses and the "fell" (weaving point) of the cloth, the ends run through the slots (dents) formed between closely spaced vertical flat wires of the "reed" (FIG. 3).

A bell-crank-driven lever, called the "lay," carries the reed forward to push the weft yarn into the cloth and then back out of the shuttle's path. The woven fabric passes over the "breast-beam" and around a positively driven take-up roll and onto a winder, the "cloth roll."

The shuttle, carrying the weft yarn, is propelled across the loom in flight under the impact of a blow from a rapidly moving lever, called the "picker stick." This stick, usually made of hickory wood, is accelerated rapidly by a cam control and suddenly imparts its energy to the metal-nosed shuttle as it strikes the shuttle. The shuttle darts across the loom, decelerating to a stop at the far side under the action of a spring-loaded friction drag in the "box."

In the weaving operation, each of the loom elements performs its function in proper sequence, which is determined by cams and gearing. The order in which the operations occur are as follows:

(1). Harnesses are positioned to raise some warp ends and lower others

(2). The lay, carrying the reed, moves to the back position toward the harnesses. As it approaches the end of its rearward travel, it is decelerated and its direction is then reversed

(3). Struck sharply by the picker stick, the shuttle trailing the weft yarn behind it, flies across the loom and comes to rest in the box at the far side

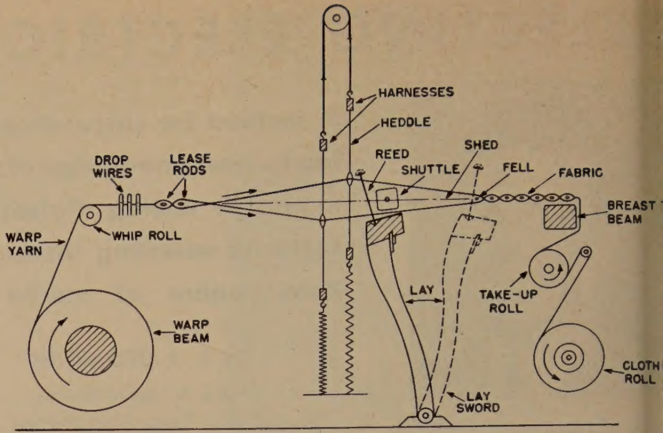


Fig. 2. A diagrammatic cross-sectional view of a modern power loom

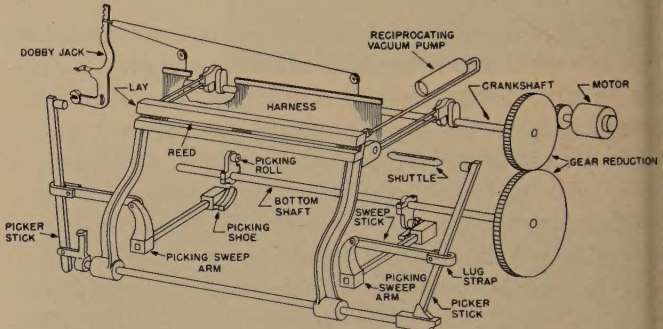


Fig. 3. A three-dimensional sketch showing the mechanical elements of a modern power loom

(4). Meanwhile, the lay is accelerated forward and the reed pushes the weft yarn into the fabric

(5). As it nears its frontmost position, the lay must be decelerated and its direction is reversed once again

(6). A ratchet on the end of the take-up roll is notched forward by a pawl driven from the lay motion.

The cycle then repeats as the harnesses change position and the next pick is made.

To obtain uniformity in the finished product, the warp yarns must be held under tension at all times. A friction brake or other hold-back mechanism is applied to the warp beam to accomplish this.

Often, in order to weave certain patterns in the fabric, special motions—such as those provided by leno or Jacquard attachments—are added to the loom. Also, on some looms, there is furnished a reciprocating pump (FIG. 3) whose function is to supply a vacuum to an automatic bobbin-changing mechanism. For purposes of this article, the effect on load of such auxiliary equipments is not considered, since they are not universally encountered.

PROTECTION

If a warp or filling yarn should break, the loom must be stopped to prevent weaving any appreciable lengt of faulty fabric. Special electric and mechanical detection devices are provided on the loom to signal the occurrence of such a break and cause the clutch to becom disengaged.

Occasionally, for any one of several reasons, th shuttle speed on a pick may be slower than normal, o e shuttle may even fail to complete its flight. If the uttle has not boxed by the time the lay swings forard to drive the weft yarn home, there is danger at it will be swept forward by the reed and pushed to the fell of the cloth. Many warp yarns would be roken and irreparable damage would be done to the bric when the "smash" occurred, necessitating a latively long shutdown for redrawing the broken arp yarns.

To protect against such an occurrence, means are rovided for checking the shuttle position to insure at its flight is true and on schedule early in the lay's rward swing. If the shuttle is not on its true course at is time, the "bang-off" protective mechanism operates simultaneously declutch the motor and position a straining rod, thus halting the forward travel of the y. For such a brute-force method to succeed in stoping the loom without causing failure of mechanical elements, the clutch must be disengaged sharply because t that point in the cycle the energy stored in the loom arts is at its maximum.

HE LOOM DRIVE

The standard fly-shuttle loom drive consists of a ll-voltage starting switch and a single induction otor (Fig. 4) of either 4- or 6-pole design whose ratg ranges from ½ to 2 hp. To protect against the ossibility that the motors may become plugged with nt from the weave-shed atmosphere, they are of tally enclosed construction. The sleeve-type woolarn-packed bearing, which has proved successful over he years in loom-motor applications, is standard day. The breakdown torque of the loom motor is pproximately twice that of the general-purpose motor. he axial length of the motor is kept at a minimum so hat it does not increase the over-all floor area required.

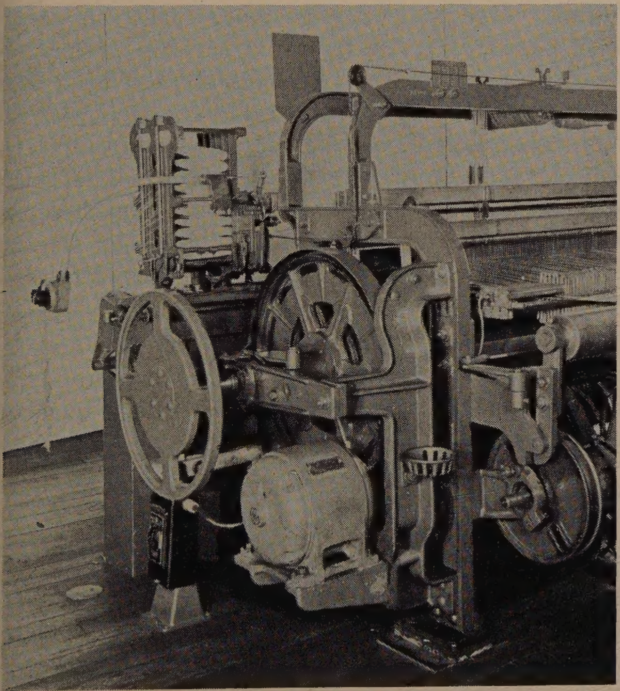


Fig. 3A. An automatically operated modern weaving loom, showing the motor end of the loom

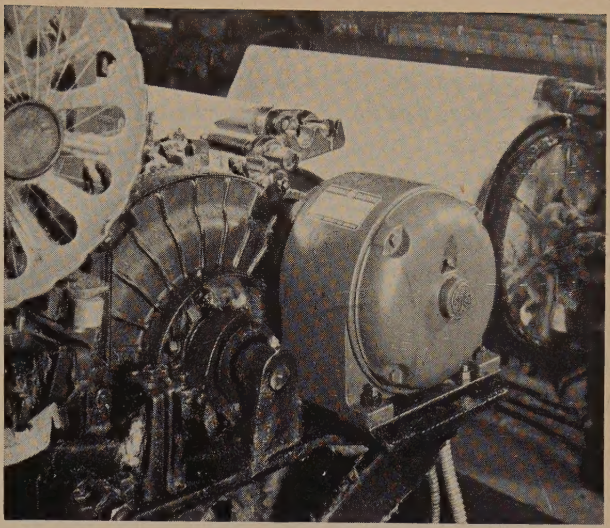


Fig. 4. A motor drive mounted on a modern power loom

The motor is coupled to the machine through a spur-gear reduction and a clutch. Starting and stopping the loom is accomplished by operation of the clutch mechanism, the motor being permitted to run continuously.

LOOM LOAD

The load imposed on the motor by the various parts of the loom can best be studied by considering the energy required to drive each element individually. Since some of the parts have widely varying velocities, it is better to consider them on a torque basis and to refer the torques to the motor shaft. The more important components of the total load are:

(1). Torque to overcome friction
(2). Torque to drive the lay
(3). Torque to drive the shuttle
(4). Torque to actuate the harnesses
(5). Torque to drive the air pump (if included)
(6). Torque to actuate a leno motion or Jacquard head (if any)
(7). Torque to actuate many small devices, such as cloth beam, dobby (harness-motion control), etc.

For analysis, one pick is considered as one cycle with zero degrees of the crankshaft taken at front dead center of the lay and with 180 deg at back dead center.

The friction of the loom consists of the actual friction of all bearings, cams, and sliding contacts, and also the constant portion of the unrecoverable part of the energy that goes into driving each part. Friction is assumed constant for purposes of analysis, but in practice it varies widely in a relatively short time with changes in lubrication of the various bearings.

Fig. 5 is a plot of friction torque versus speed derived from 21 tests on a loom of one size and make. Although this machine was well run in and had expert attention while being tested, friction load varied at each speed considerably. Test 10 shows abnormally high friction preceding a bearing seizure but at the time of the test no distress was noted. The high friction did not show up until the test results were analyzed.

Fig. 6 shows, in graphic form, the torque required to drive each of the various loom parts. The torque is plotted against lay position and this also roughly represents time. Friction is considered ideally constant and is represented by a horizontal line *A*.

The lay is a heavy mass oscillating about its center, and considerable torque is necessary to accelerate and decelerate it. Since it is accelerated and decelerated twice per pick, the frequency of the torque (curve *B* Fig. 6) is twice that of the pickage. During the deceleration, the energy can be recovered and returned to the system either as electric energy or as kinetic energy stored in the effective moment of inertia of the loom. The torque is thus a curve with equal areas above and below the zero line and is a sinusoid as a first approximation. The short connecting rods and the angularity of these rods introduce some harmonics, but these are not important as far as the motor is concerned, although they may be of considerable interest to the loom designer.

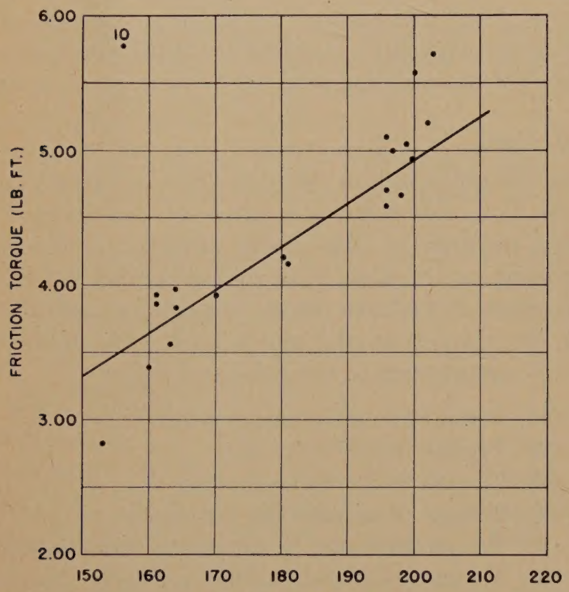


Fig. 5. Plot of loom friction torque versus loom speed (Based on 21 tests)

The shuttle is struck by the picker stick, which in turn is struck by a cam with a very steep rise. This gives the picker stick its high acceleration and demands a sharp peak of torque from the drive system. The shape of the cam, adjustment of linkages, firmness of springs in the shuttle box, and probably several lesser factors affect the configuration and amplitude of the torque curve. The full-line curve *C* in Fig. 6 is believed to be a fair representation of the actual torque values. For purposes of calculation, however, they can be approximately represented by a single loop of an eighth-harmonic sine wave, as shown in dotted lines.

The torque required to actuate the harnesses (curve *D* Fig. 6) is usually not great and its average value is included in the friction component. Unless the loom is fitted with a large number of harness frames and is weaving a complicated pattern that requires the lifting of nearly all of them at once, the variations in torque can be neglected. The load represented by the cloth-beam drive, dobby motions, and other lesser elements may similarly be regarded as constant and as a part of the friction factor.

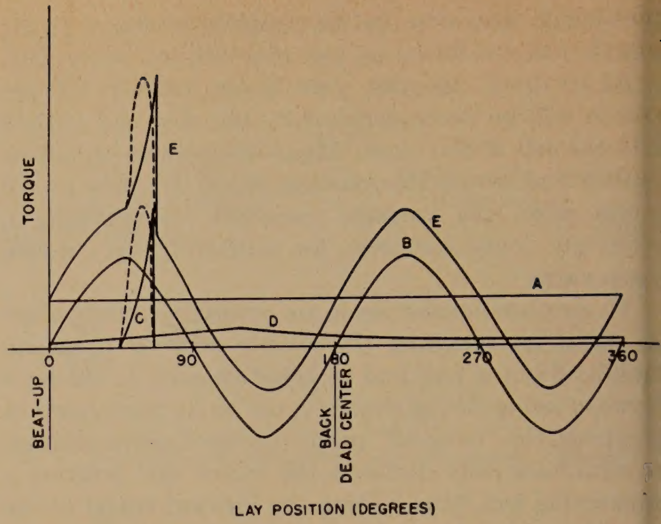


Fig. 6. An analysis of the nature of the loom load showing components of torque required to drive the loom

A: Friction
B: Lay
C: Pick
D: Harness
E: Composite

The torque necessary to drive the loom is the summation of these components and is represented by curve *E* in Fig. 6. This torque is supplied from two sources: (1) the motor, and (2) the inertia or flywheel effect of the revolving and oscillating parts of the system. The latter consists of the moment of inertia of the motor, of the revolving parts of the loom, and of the lay. The load at every instant is divided between the motor electrical torque and the energy from the rotating parts in varying proportions, depending on the motor speed-torque characteristics and the amount of system inertia. For example, if the loom were driven by an infinitely large synchronous motor, all the torque would be supplied electrically from the power line. The opposite extreme may be represented by a loom equipped with a large flywheel and coasting with the motor disconnected from the line, in which instance the flywheel would supply all of the torque. The actual operation, however, is a compromise between these two conditions, and the load is divided between the two sources in varying degree, as is illustrated in Fig. 7.

Fig. 8 is a tracing of an oscillogram of the current and watt input to a motor driving a loom. The similarity between the shape of the measured motor-input curve and that of the calculated total load curve in Fig. 7 is apparent.

CALCULATIONS

The foregoing analysis suggests that the motor output can be approximated by calculation provided the components can be treated additively. They may be so treated provided the motor operates on that portion of the motor speed-torque curve which is essentially straight, a condition existing over the usual operating range. A relatively simple loom is considered for purose of illustration; additional components for pump, eavy harness, leno, etc., can be added if desired.

As previously indicated, friction torque is considered onstant and is represented by curve A in Fig. 6.

The torque to drive the lay is treated as a sine wave vith a frequency of twice the number of picks and is epresented by $B \sin \frac{(4\pi P)t}{60}$ where B is the peak acelerating torque and P equals the picks per minute.

The variations in the harness torque are neglected, ut the average of the torque wave is included in the riction torque A.

The torque to produce the pick is assumed to be a ingle positive loop of an eighth harmonic starting at he peak of the torque wave of the lay. The energy nder this wave is made equal to the kinetic energy f the shuttle as it leaves the box, and the maximum alue is represented by B'.

Motor torque can be approximated over the useful perating range by Cs, where s is the slip of the motor t any instant and C is the ratio of rated torque to ated slip.

The torque delivered by the flywheel is $I\,ds/dt$ where is a function of WK^2 and ds/dt is the acceleration of he flywheel.

These components of torques are equated and the ifferential equation reduced to the following:

$$_{\max}=A+\frac{B}{\sqrt{1+\left(\frac{PWk^2N_0^2S_{\mathrm{FL}}}{7.75\times 10^6R}\right)^2}}+\frac{B'}{\sqrt{1+\left(\frac{4PWk^2N_0^2S_{\mathrm{FL}}}{7.75\times 10^6R}\right)^2}}$$

$$=A+D+F$$

$$_{\mathrm{rms}}=(A^2+0.5D^2+0.048F^2+0.04AD+0.03DF)^{\frac{1}{2}}$$

$$_{\min}=N_0\left(1-\frac{T_{\max}}{C}\right)$$

$T_{\max}$ is the maximum torque imposed on the motor nd is used in conjunction with the breakdown torque o determine the ability of the motor to carry the load nder adverse conditions.

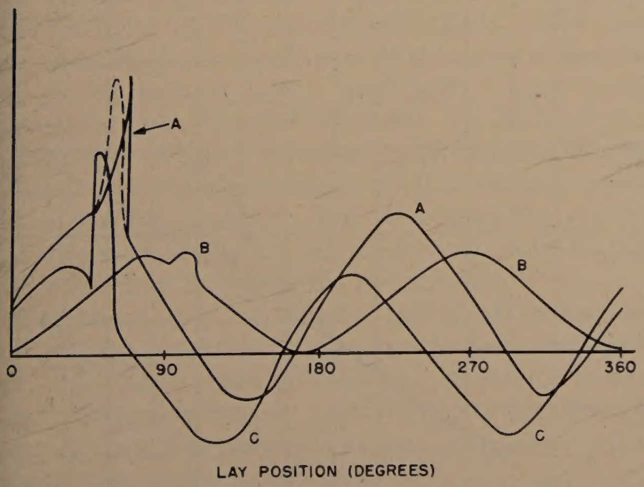


Fig. 7. An analysis of the manner in which energy is drawn from motor and rotating parts to drive a loom over its cycle (torque delivered to the loom)

A: Total torque requirement
B: Delivered by motor (electric)
C: Delivered by flywheel

T_{rms} is the root-mean-square of the motor output and is used to determine motor heating.

$N_{\min}$ is the minimum speed of the motor at the instant of heaviest load.

A = Friction torque
B = Peak torque to accelerate lay
B' = Peak torque to accelerate shuttle
P = Number of picks per minute
Wk^2 = Total system Wk² referred to motor
N_0 = Motor synchronous speed
R = Motor horsepower rating
S_{FL} = Motor rated slip at full load
C = Ratio of motor rated torque to rated slip
D = Peak motor torque to drive lay
F = Peak motor torque to drive shuttle

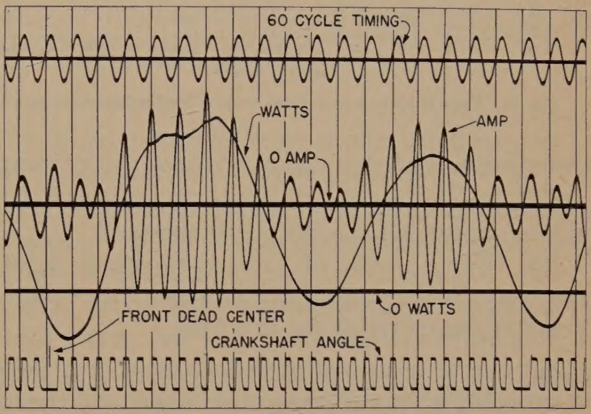


Fig. 8. Oscillogram taken during a loom test

All of the parameters, with the exception of friction torque, can be obtained by weighing and measuring, or are well known to loom designers. The friction must be estimated or determined by test. These equations lend themselves to fairly rapid columnar calculation, and although only approximate they are sufficiently accurate for motor application, as proved by comparison with oscillographic tests. By their use, it is not difficult to compare the operation of motors with various combinations of characteristics and to select the one with well-balanced performance.

TESTING

Looms are tested to check motor operation and weaving ability, as previously outlined. In addition, tests can be used by the mill operator to determine that the loom fixer's adjustments hold friction and peak torques within the limits anticipated by the loom designer.

From the oscillogram, Fig. 8, it is apparent that the watts input and the current input vary widely during different parts of the cycle. Ordinary meters connected to the circuit show wide needle swings, and, unless properly read, give meaningless results. However, reliable results can be obtained if proper precautions and techniques are employed.

Practical quantitative values descriptive of loom and motor operation are calculated from motor-watt input

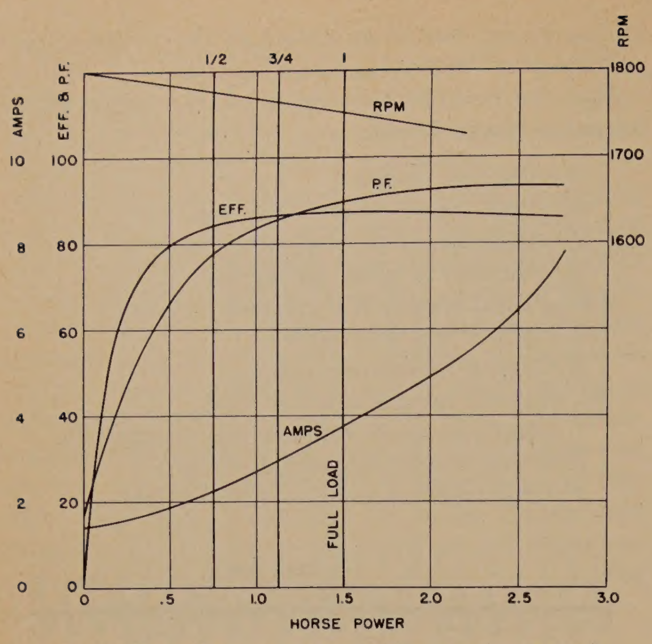


Fig. 9. Typical loom-motor characteristic curves (steady-state)

measurement, with due regard to these two principles:

(1). At any instant, the input to the motor is the sum of motor output and motor losses.

(2). Over a period of time, the average input to the motor is the sum of the average output plus the losses of the motor at the rms load.

Input can be measured in various ways, but the one that probably gives the greatest accuracy and the most complete information is an oscillographic recording of watts input to the motor. The oscillograph should be one that shows watts as an integrated curve and not as an envelope of an a-c wave. The average of the watt curve (Fig. 8) is the average watt input to the motor and can be obtained by measuring ordinates or by means of a planimeter.

The rms of the watt trace can be calculated by measuring the ordinates, squaring them, averaging the squared values, and extracting the square root—a tedious process. That value can be determined also by the use of an Amsler Mechanical Integrator, a device that reads squared areas in the same manner that an ordinary planimeter reads areas, and the rms value can be calculated as easily as the average.

The next step is to determine the watts loss of the motor. This can be done by referring to a test of the motor taken under steady-load conditions (Fig. 9), and determining the loss at the same watts input. A watts-loss curve, such as that in Fig. 10, is a more convenient form for this work. This curve is computed from efficiency data of Fig. 9 and is a plot of watts input versus watts loss. In a similar manner, torque versus watts input, and speed versus watts input, also may be plotted (Fig. 10). The average output of the motor is then the difference between average input watts and the watts loss, and can be converted to horsepower by dividing by 746 or to torque by multiplying by $\frac{7.04}{\text{avg rpm}}$. This is the friction torque of the loom.

Since the friction torque varies greatly, as illustrated in Fig. 5, a comparison of motors on the basis of tested losses is fruitless unless the motor operation is referred to a common friction load. This is done by determining the difference a between the friction determined in a particular test and the accepted nominal value. Let rms_0 be the tested rms output of the motor and F_0 the tested average output. The corrected rms output is:

$$\text{rms}_c = \sqrt{\text{rms}_0^2 + 2aF_0 + a^2}$$

From the corrected rms output, the corrected losses are determined from the curve (Fig. 10) plotted from steady-load conditions.

Peak values of torque, and maximum and minimum values of speed, can be determined, at least approximately, by entering Fig. 10 with the proper ordinate of the watt trace.

Loom motors can be tested without the use of an oscillograph, with only a slight loss of accuracy and detail. The average watt input can be read on a polyphase wattmeter by reading the maximum and minimum positions of the needle as it swings through a rather wide range and then averaging the two readings. A better way is to use a watthour meter and count the revolutions of the disk for a minute or so, to obtain the average watts over this period of time.

The rms current can be measured by an ordinary electrodynamic or soft-iron ammeter by noting the maximum and minimum positions of the needle and taking the reading halfway between the extremes. This is the rms value, since the scale of such an instrument is divided to read rms units. Calculations based on such test results are the same as those outlined in this article except that the rms load is determined from

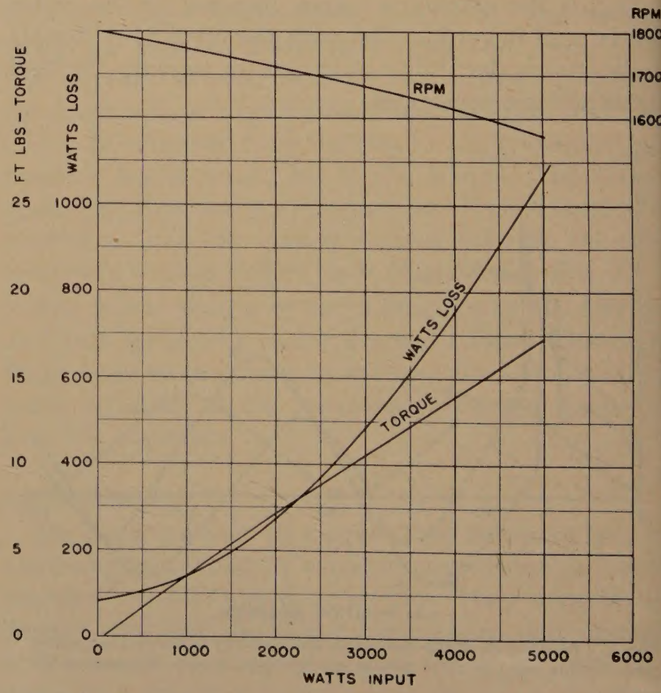


Fig. 10. Typical loom-motor curves of torque and losses versus watts input, based on data of Fig. 9

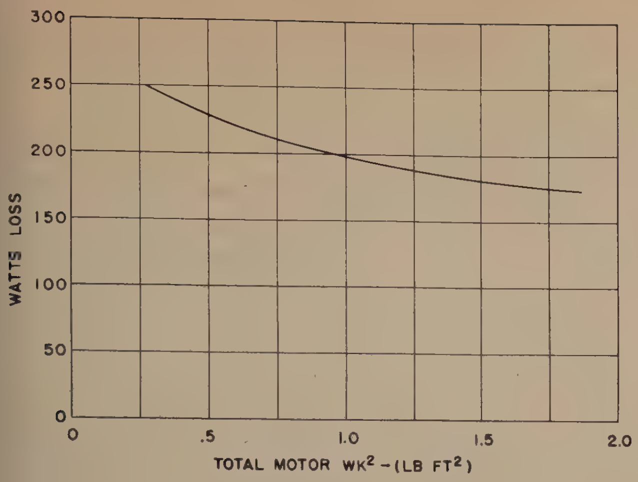


Fig. 11. Curve illustrating effect of inertia on loom-motor losses

a current curve rather than from a watt curve. A hot-wire ammeter can also be used to advantage, since the needle swings are not as great as with the conventional type of indicating instrument. However, hot-wire instruments have practically no overload capacity and are thus prone to go out of calibration.

A fair approximation of peak torque can be obtained by measuring the peak value of watts input with a pointer-stop polyphase wattmeter. With this type of instrument, the needle is held up-scale by an adjustable stop so that it moves from the stop only during the maximum part of the cycle. By using such a meter, the effect of the inertia of the meter itself is eliminated and a true peak value is observed. If a pointer-stop meter is not available, an ordinary instrument can be used by removing the cover glass and holding the needle in an up-scale position with some small tool such as a pencil. This value of peak watts is used in the same manner as is that read from an oscillogram.

EFFECT OF WK^2

As has been explained and as illustrated in Fig. 7, the torque required to drive the loom is supplied in part from the power line and in part from the rotating parts of the system. The division of load varies depending on the amount of flywheel effect in the mechanical system and the slope of the motor speed-torque curve. Since the speed of the flywheel must drop to give up energy, it may be deduced that a motor with a steep speed-torque curve is indicated. However, the efficiency of a motor decreases with decreased speed, and motor input (output plus losses for a given load) tends to increase. Thus, the gain expected from decreasing the load on the motor by letting the inertia do more work is offset to some degree by additional motor losses.

For this reason, a low-slip highly efficient motor having high breakdown torque can be just as efficient, and give just as stable operation as one having greater Wk^2, but lower efficiency, greater slip, and lower breakdown torque. The operation of the loom appears to be exactly the same in both cases.

The addition of Wk^2 always reduces the amount of load on a motor of a given electrical design and reduces the motor losses as well as its speed variations when driving a pulsating load. The curve shown in Fig. 11 illustrates how the losses of a given design of motor were reduced by the addition of Wk^2. It is apparent that the amount of reduction is appreciable but that the gains diminish after a reasonable amount of flywheel has been added. A loom motor with a built-in flywheel is shown in Fig. 12.

The reduction in losses is so great that it is often found entirely feasible to reduce motor size one whole step, and still satisfy the requirements of good motor application and loom operation.

Another consideration favoring inclusion of appreciable rotating inertia on the motor shaft is that 1200-rpm motors may be substituted for 1800-rpm motors without incurring an increase in speed variation. This is not possible with conventional motors because the effective motor rotor Wk^2, which varies with the square of the motor speed, is appreciably less when lower speed motors are used.

MOTOR SELECTION

To make certain that the motor will drive the loom without distress, two criteria are used:

(1). The peak torque under maximum load on the motor should not exceed two thirds of the breakdown torque of the motor

(2). Motor losses should not exceed the steady-state load losses that give a reasonable temperature rise.

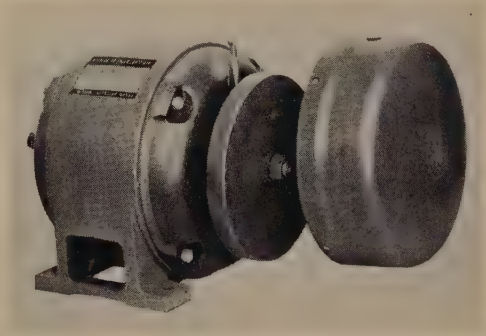


Fig. 12. Loom motor with flywheel, the cover of which is removed to show the wheel

By limiting peak torque to about two thirds of breakdown torque, sufficient margin is provided to insure satisfactory operation under adverse conditions of 10 percent undervoltage and temporary load increase of about 20 percent, as might be experienced during the loom break-in period. This safety factor assures that the speed will not drop so much that the picking becomes erratic.

Loom motors are rated 40 C rise on the windings at rated horsepower; this temperature is measured by thermometer during operation at rated load and under steady-state conditions. Traditionally, however, motors have been applied on the pulsating loom load to operate at about 55 C rise on the windings. (Overload protectors have always been selected in the range of 140 to 160 percent of rated full-load current.) Although the method of rating and applying motors to looms

(Continued on next page)

What are your Requirements? FOR CORROSION RESISTANT TUBING

Superior supplies tubing (up to ⅝" OD) in all these analyses of corrosion resistant metals:

Stainless Steels; A.I.S.I. 304, 309, 310, 316, 321, 347, 446, 403, 430, 502.

Beryllium Copper, Nickel, Monel, "K" Monel, Inconel, "Nichrome V," and other Nickel alloys; 36%, 42%, and 52% Nickel Iron.

Some are available in both seamless and WELDRAWN*.

In choosing metal tubing for particular products and conditions it is important to consider the degree of corrosion action to be met, but in addition, the combination of other properties such as formability, high strength at high temperatures, machinability, etc., must dictate the *one proper analysis* to be used.

Our metallurgists and engineers will be pleased to work with you and suggest the analyses and grades of tubing best suited for your particular products and service conditions.

Write for Bulletin No. 31

**U.S. Trademark*

Superior

THE BIG NAME IN SMALL TUBING (.010" TO ⅝" O.D. MAX.)

For Superior tubing on the West Coast, call PACIFIC TUBE COMPANY, 5710 Smithway Street, Los Angeles 22, Cal. ANgeles 2-2151.

SUPERIOR TUBE COMPANY
2040 Germantown Ave.
Norristown, Pennsylvania

ILSCO PRODUCES MANY TYPES OF ELECTRICAL CONNECTORS

Write for 54-page illustrated catalog

ILSCO · COPPER TUBE & PRODUCTS, INC.
CINCINNATI 27, OHIO

SELECTING LOOM DRIVES

(Continued from preceding page)

differs from that for standard motors, the application specification that winding rise should not exceed 55 C is the same as for a conventional totally enclosed motor. This is the maximum temperature rise considered for long trouble-free insulation life. As in any motor of loom-drive size, the outside temperature is considerably less than that of the winding and is generally in the 40 C rise range. Furthermore, this has become the practical limit in the minds of many, on the basis that a higher temperature affects the humidification around the loom. Therefore, a practical rule of application that insures meeting both requirements is:

Select a motor such that the temperature rise exceeds neither 40 C on the frame nor 55 C on the windings. Both temperatures are to be taken with mercury thermometers, or by an equivalent method.

The temperature rise of a motor on the loom cycle can be determined by comparing the rms losses, determined as outlined in this article, with the losses for a given temperature rise under steady-state conditions. This eliminates the necessity of conducting a heat run on the loom cycle.

CONCLUSIONS

(1). The loom load is of a pulsating character, and the motor applied must have characteristics different from those of general-purpose machines. Energy required at every instant must be supplied in part by electrical air-gap torque and in part from energy stored in the Wk^2.

(2). Loom motors which give equivalent performance can be made with a wide range of designs, provided the characteristics are properly balanced.

(3). The addition of a sizable flywheel reduces motor load, makes it possible to use a smaller motor in some cases, and makes the operation of 1200-rpm and 1800-rpm motors equivalent.

(4). Knowing only the basic constants of a loom and motor, performance of the combination may be calculated.

(5). Motor tests on looms give results capable of reliable interpretation. Suitable instruments are:

(a). An electrodynamic or soft-iron type ammeter to read rms amp
(b). A watthour meter or a polyphase wattmeter for reading average watts
(c). An a-c voltmeter to indicate line voltage.

An oscillograph may be substituted for these three instruments for more precise results.

(6). Friction load varies from loom to loom and from time to time on a given loom. This demands that a representative value of friction be established, and that all tests be corrected to a common base. In comparative testing, individual readings must be corrected to a nominal value before drawing conclusions.

High Vacuum--Production Booster!

INCREASED sales of air conditioning systems and store coolers challenged the General Electric Company plant at Bloomfield, N. J., for faster production of refrigerating coils.

Each coil must be absolutely leak proof. Underwater tests of coils filled to 300 pounds of air pressure sometimes failed to disclose fine leaks. A DPI high vacuum pump was installed by General Electric production engineers to exhaust each coil. With it, the most minute leaks are detected. Leakage troubles with coils in the field have been virtually eliminated . . . a happy result for the sales and service departments.

The DPI High Vacuum pump also cut exhaust time, so that batches of coils are vacuum pumped, dried, ready for the introduction of freon gas at a pace three times faster than formerly.

High Vacuum is finding more and more commercial applications—in fractionating many substances once thought undistillable, in making vitamins and vaccines, in processing foods and chemicals. It has important places in electronics, metallurgy, nucleonics. Possibilities seem unlimited.

Can you use high vacuum in your business, for producing a better quality product, to cut manufacturing costs, or for exploratory research that may convert waste material into profitable commodities? DPI welcomes inquiry. Write

DISTILLATION PRODUCTS, INC.
773 RIDGE ROAD WEST • ROCHESTER 13, N. Y.

Manufacturers of Molecular Stills and High-Vacuum Equipment; Distillers of Oil-Soluble Vitamins and Other Concentrates for Science and Industry

FRACTIONAL-HORSEPOWER GEARMOTORS . . . THEIR CLASSIFICATION AND APPLICATION

For economy, space-saving, reduction of maintenance, and simplified mechanical design, these units are being used advantageously today and new uses are still being found

A H Lee

By A. H. LEE
Fractional-horsepower Motor Division
General Electric Company

A GEARMOTOR is the combination of an electric motor and a gear reducer built and assembled to form an integral unit.

The need for such an electric drive arises from the many applications where the speed of the driven device must be lower than the speed of motors that can be practically and/or economically built. To obtain the lower-speed drive, a motor of conventional speed (such as 1800 rpm) is combined with the required speed reducer to form a gearmotor. The higher-speed motor is inherently more efficient, which reduces power consumption, and is smaller in size to the extent that the gearmotor unit actually represents an over-all saving in size and space.

In these many cases where the speed of the driving shaft must be below that for which motors can be economically built, the gearmotor has proved itself, in most instances, to be highly advantageous over other types of speed reduction. It provides a positive connection, without slippage, between the motor and the driven load. Its gears are fully encased to insure protection from foreign matter and to permit adequate lubrication for long life and quiet operation. In short, it is more compact and saves space; it is more efficient and saves power; it is easily and quickly installed; it is quiet in operation; it provides a high degree of safety to personnel; and it requires practically no maintenance except occasional lubrication.

The mounting feet for the unit are cast integrally with the gear housing, thus forming a strong mounting to absorb shock loads and also the torque reaction of the low-speed shaft. The motor stator is mounted directly on the gear housing, thereby giving compactness as well as insuring permanent precision alignment between motor-shaft pinion and mating gears.

Two principal types of gear reduction are used: the planetary and the worm-gear. The planetary type, shown in Fig. 1, has its driving shaft in line and concentric with the motor shaft. It consists essentially of the center pinion on the motor shaft, a stationary internal ring gear concentric with this pinion, and three planet or idler gears, spaced 120 deg apart, that mesh with and form the connecting link between the center pinion and the ring gear.

The planet gears are carried in a supporting cage on its own two bearings. When the center pinion rotates, it causes the planet gears to rotate and to advance along the teeth of the internal ring gear, with which they mesh. As the planet gears advance, so must their supporting cage, which is so designed that one end of it is brought out of the gear case to form the low-speed drive shaft. In this system, the load is distributed between the three planet gears—that is, distributed between three points 120 deg apart on both the center pinion and the internal ring gear. With this arrangement, the separating forces and the bending moments are neutralized in the system. These features give this

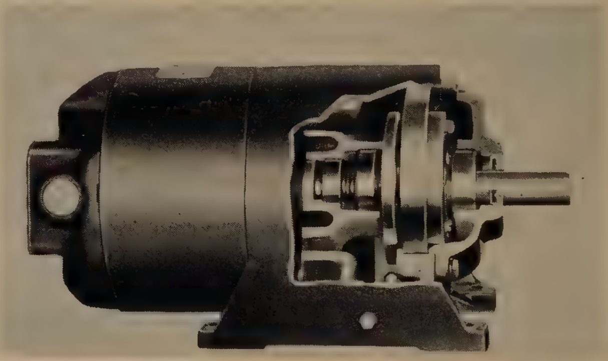


Fig. 1. Concentric-drive gearmotor with the gear housing cut away to show internal parts

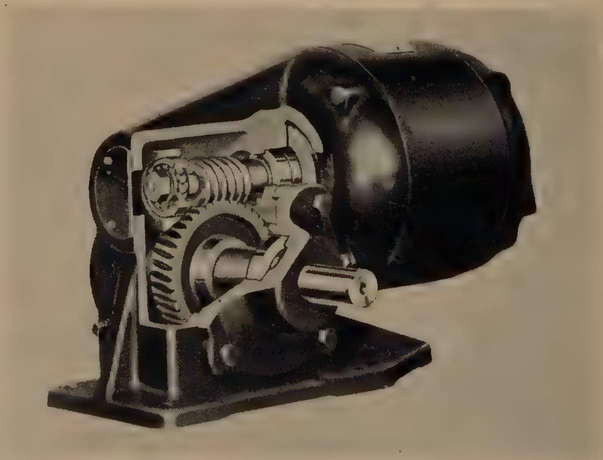
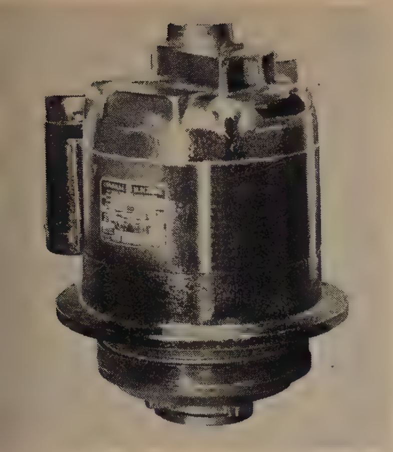


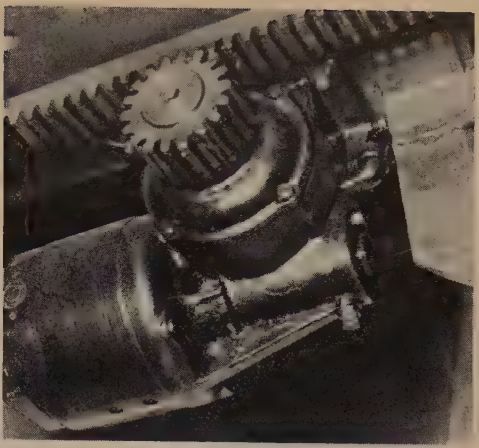
Fig. 2. Right-angle-drive gearmotor, with the gear housing cut away to show internal parts. Approximately one-fourth size

---

This article is so paged that without mutilating other articles, it can be readily removed for filing as a group of full-size consecutive pages.—Editor



Ball-bearing open concentric-shaft ½-hp gearmotor for a floor machine. Approximately one-sixth size



One of two reversible, 1/3-hp d-c gearmotors, with wall-mounted worm- and planetary-reduction unit (99 rpm), geared to the rack of observation-bridge travelers under the dome of an astronomical observatory

Squirrel-cage induction ¾-hp gearmotor, flange-mounted with high-ratio reduction unit (25 rpm), driving a chili kettle

system a decided advantage over the single pinion-and-gear arrangement.

For higher gear ratios than are practical in a single planetary reduction, two such reductions are assembled in tandem in the same housing.

The worm-gear reduction carries a heat-treated steel worm on the motor shaft and a cast alloy-bronze worm wheel on the low-speed shaft, which is at right angles to the motor shaft, as shown in Fig. 2. This type of gear reduction permits relatively high ratios in a single stage of reduction in the minimum space. The efficiency of worm-gear reduction is not as high as that of the planetary type, but on some applications it fits more compactly into the device than the in-line shaft.

In the application of gearmotors careful attention must be given to the load and to the duty cycle, as it affects the gears as well as the motor. It is important to recognize that a gear reducer, through its meshing teeth, forms a solid coupling between the load shaft and the motor. In contrast, the torque of a motor is transmitted from stator to rotor through magnetic lines of force, which permit a certain resiliency during load fluctuations and allow the rotor to slip. Furthermore, on sudden peak loads, the inertia of the rotor gives it stored kinetic energy, which adds to the electrical output of the motor to transmit additional torque through the gears. In the motor such peak loads represent only some additional heating, but in the gears they indicate increased tooth pressures and greater tooth wear. When such peak loads occur rather frequently, the gears must be selected for these values rather than for the value of the average load.

The AGMA has thoroughly classified gear applications according to operating conditions. Essentially, there are three classes of service: Class I, in which the load is steady and does not exceed the rated load and operation does not exceed 8 hours per day, but with moderate shock loads permitted if the service is intermittent; Class II, in which the load is steady and does not exceed the rated load for 24-hour-per-day service, but with moderate shock loads permitted for 8-hour-per-day service; and Class III, for moderate shock loads on 24-hour-per-day service, and heavier shock loads on 8-hour-per-day service.

The following AGMA Table of Application Classifications lists a broad variety of applications and the class of gear nominally used in each application:

Application	8-to-10-hr Service	24-hr Service
Agitators		
Pure liquid	I	I
Variable density	II	II
Blowers		
Centrifugal	I	I
Lobe	II	II
Brewing & Distilling		
Bottling machinery	I	II
Brew kettles, continuous-duty	II	II
Cookers, continuous-duty	II	II
Mash tubs, continuous-duty	II	II
Scale hopper (frequent starting peaks)	II	II
Car Dumpers	II	III
Car Pullers	II	III
Clarifiers	I	II
Classifiers	II	II
Clay-working Machinery		
Brick press	III	III
Briquette machine	III	III
Clay-working machinery	II	II
Pug mill	II	II
Compressors		
Centrifugal	I	II

Application	8-to-10-hr Service	24-hr Service
Compressors (Cont'd)		
Lobe	II	II
Reciprocating multicylinder—adequate flywheel (within 3% cyclic variation)	II	III
Reciprocating, single-cylinder	Refer to Factory	
Conveyors (Uniformly loaded or fed)		
Apron	I	II
Assembly	I	II
Belt	I	II
Flight	I	II
Oven	I	II
Screw	I	II
Conveyors (Heavy-duty or dual-drive—not uniformly fed)		
Apron	II	II
Assembly	II	II
Belt	II	II
Flight	II	II
Oven	II	II
Screw	II	II
Reciprocating	III	III
Shaker	III	III
Cranes & Hoists		
Main hoists, medium-duty	II	II
Main hoists, heavy-duty	III	III
Skip hoists	II	II
Travel motion	II	II
Trolley motion	II	II
Dredges		
Cable reels	II	II
Conveyors	II	II
Cutter-head drives	III	III
Jig drive	III	III
Screen drive	III	III
Stackers	II	II
Utility winches	II	II
Elevators (Conveyor type—same as conveyors)		
Freight	Refer to Factory	
Passenger	Refer to Factory	
Fans		
Centrifugal	I	II
Cooling towers	II	II
Large (mine, etc.)	II	III
Light, small-diameter	I	II
Food Industry		
Beet slicer	II	II
Cereal cookers	I	II
Dough mixer	II	II
Meat grinder	II	II
Hoists—See Cranes		
Laundry Washers	II	II
Laundry Tumblers	II	II
Line Shafts		
Driving processing equipment	II	II
Other line shafts	I	II
Machine Tools		
Notching press (belt-driven)	I	II
Plate planers	III	III
Punch press (gear connected to load) and shears	III	III
Other machine tools—main drives	II	II
Auxiliary drives (feed-traverse, etc.)	I	II
Metal Mills		
Draw-bench carriage and main drives	III	III
Forming machines	III	III
Pinch, dryer, and scrubber rolls (reversing)	Refer to Factory	
Slitters	III	III
Small rolling-mill drives	III	III
Table conveyors (nonreverse)	II	II
Table conveyors (reversing)	Refer to Factory	
Wire-drawing and -flattening machines	III	III
Mills (rotary type)		
Ball	III	III
Cement kilns		III
Dryers and coolers		II
Hammer	III	III
Kilns	II	III
Pebble	II	III
Mills (Cont'd)		
Rod	III	III
Tumbling barrels	III	III
Mixers		
Concrete mixers, continuous-duty	II	II
Concrete mixers, intermittent-duty	I	
Constant density	I	II
Irregular density	II	II
Oil Industry		
Chillers	II	II
Oil-well pumping (not over 150% peak torque)	III	III
Paraffin filter press	II	II
Refineries		
Rotary kiln	II	II
Paper Mills		
Agitators (mixers)		II
Bleacher		II
Beater and pulper		III
Calenders		III
Conveyors		II
Couch		III
Cylinders		II
Dryers		III
Felt stretcher		II
Jordans		III
Presses		III
Stock chests		III
Suction roll		III
Winders		II
Pumps		
Centrifugal, with surge tanks or equivalent	I	II
Centrifugal, without surge tanks	II	II
Gear and rotary, constant-density fluid	I	II
Gear and rotary, variable-density fluid	II	II
Proportioning pumps	II	III
Reciprocating, with open discharge	I	II
Reciprocating, multicylinder, double-acting	II	II
Reciprocating, single-cylinder	Refer to Factory	
Rubber Industry		
Mixer	III	III
Rubber calender	II	III
Rubber mill	III	III
Sheeter	III	III
Tire-building machines	II	II
Tire- and tube-press openers	I	I
Tubers or strainers	II	II
Sewage-disposal Equipment		
Inside service	I	II
Screens		
Rotary—stone or gravel	II	II
Traveling water-intake	I	I
Textile Industry		
Batchers	II	II
Calenders	II	II
Card machines	II	III
Dry cans	II	II
Dyeing machinery	II	II
Looms	Refer to Factory	
Mangle	II	II
Nappers	II	II
Soapers	II	II
Spinner	II	II
Tenter frames	II	II

When selecting the electric motor, the problem is the same as that of selecting a motor for any other application. The full-load torque must be determined; also the required starting and maximum torque. In addition, the motor may have to be reversible either instantly or from the standstill position. Whatever the load condition and duty cycle may be, these factors must be integrated to determine that they are within the safe heating limits of the motor. So it is highly mportant when applying gears to take into full account he peak torque loads, and their frequency of occur-ence, as well as the average load and the hours-per-lay of operation. AGMA data in Fig. 3 show how the llowable intensity of shock varies with peak loads.

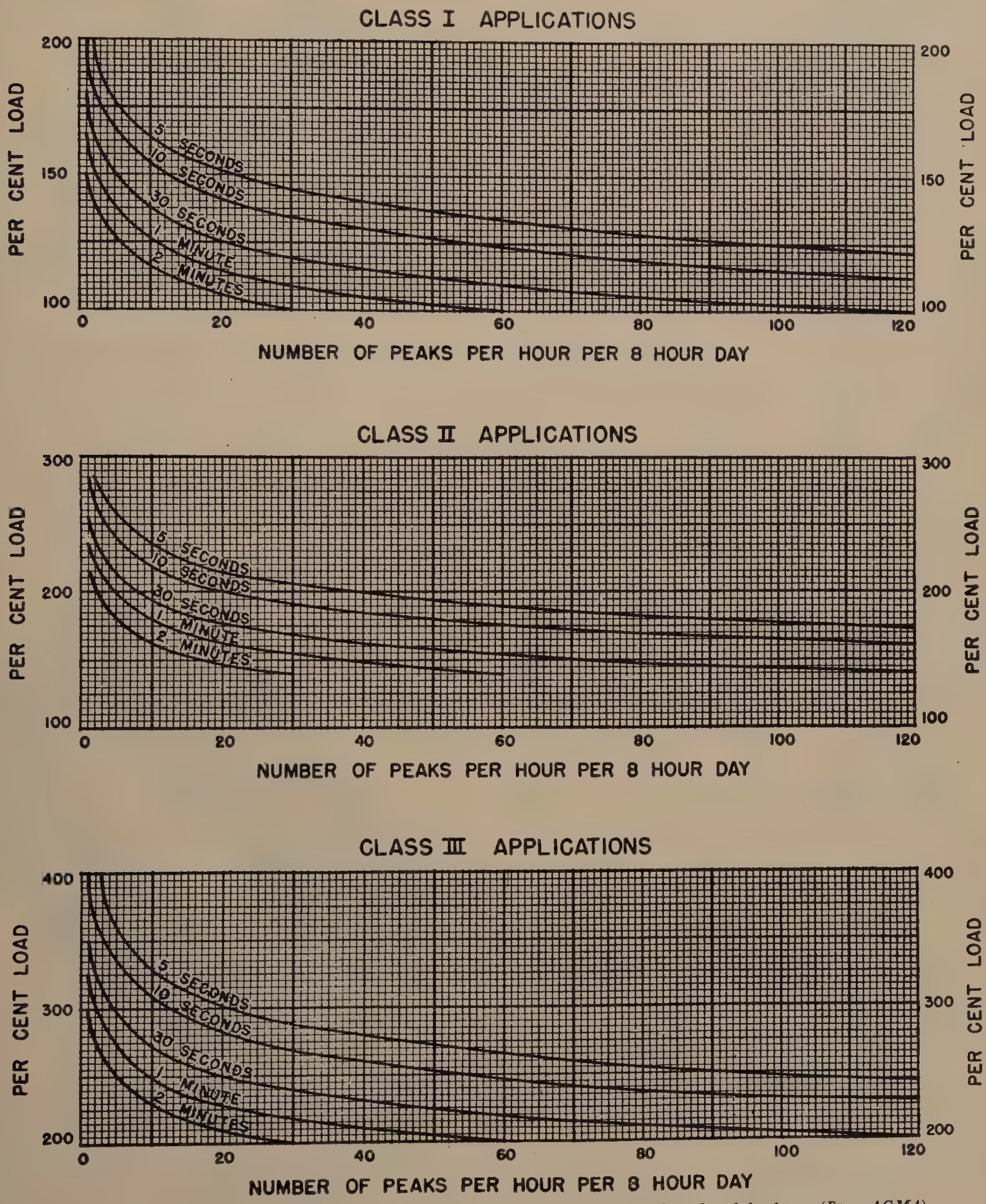


Fig. 3. Variation of allowable intensity of shock with the frequency and duration of peak loads (*From AGMA*)

The uses for gearmotors are both numerous and varied. Wherever a low-speed drive is required, it is essential from an over-all economic standpoint to first consider the use of a gearmotor for the application. Large numbers of gearmotors have been used on such applications as conveyors, drive heads and feed mechanisms for machine tools, pasteurizers and bottle washers for dairy equipment, floor-polishing machines, electric door operators, textile machinery such as traverse mechanisms, tension control, guiders, and take-up and let-off reels; laboratory equipment, paint- and dough-mixing machines, control devices such as timers and rheostats, chemical and other low-speed pumps and metering devices, and general factory equipment. These examples represent only a few of the many applications on which gearmotors are being successfully and advantageously used today. And yet new uses for gearmotors are constantly being found.

There are beyond doubt many new places where engineers will find that gearmotors can be, and will be, advantageously applied to save money, save valuable space, minimize maintenance, and simplify over-all mechanical design.

IT WON'T BREAK if it's a new O.Z. ALL-BAKELITE BUSHING!

BOUNCE IT

Bounce an O. Z. All-Bakelite Insulating Bushing hard, on a concrete floor — it rebounds good as new. Add to its superior strength* these extra features and you've got a bushing that's best by any test!

- **Smooth rounded edges completely protect wire insulation during pulling and when in service.**
- **Clean, deep threads let you spin-on the bushing with a twist of the wrist.**
- **Ribbed outer surface provides a grip for slippery hands and permits tapping with a screw-driver.**

O. Z.'s New All-Bakelite Insulating Bushings are fully approved by Underwriters' Laboratories, meet all requirements of the National Electric Code.

Try a few, bounce 'em, treat 'em rough and you'll be convinced there are no all-Bakelite bushings better suited to the job . . . none so economical to use as O. Z.'s.

Available in sizes from ½ inch to 6 inches, cost no more than ordinary Bakelite bushings. Samples on request.

*56% stronger over all than all other leading all-Bakelite bushings actually tested by an independent laboratory.

CONDUIT FITTINGS • CABLE TERMINATORS
CAST IRON BOXES • GROUNDING DEVICES
SOLDERLESS CONNECTORS • POWER CONNECTORS

Buy O. Z. and you'll see why Engineers say, "They're OK if they're O.Z."

O.Z. ELECTRICAL MANUFACTURING COMPANY, INC.
262 BOND STREET • BROOKLYN 2, N. Y.

4899

ROTECTIVE ATMOSPHERES IN INDUSTRY . . Part V

Effects of furnace atmospheres of hydrogen, nitrogen, carbon dioxide, or dissociated ammonia in preventing decarburization in various heating processes

By A. G. HOTCHKISS and H. M. WEBBER
Industrial Heating Divisions, General Electric Company

ALL OF the gases listed in Table I* are included in this story of atmospheres for preventing decar- urization. The first three atmospheres listed—hydro- en, nitrogen, and carbon dioxide—are most commonly ncountered as factors in mixed gases, such as the last hree atmospheres listed—dissociated ammonia, com- usted fuel gas, and catalytically reacted fuel gas. Iydrogen and nitrogen, however, are sometimes used y themselves or with slight additions. The first four f these atmospheres will now be considered in detail, n the same order in which they are named in Table I.

When metals are heated in a decarburizing atmos- here and hardened, either by quenching from that emperature or from a subsequent heating operation, he decarburized skin is soft and subject to wear. Thin arts also have poor physical properties. If the parts ormally receive subsequent machining operations hich would remove the soft skin, there would be no bjection to it. If such operations are not scheduled, owever, and skin hardness on the parts is desired, it hen becomes necessary to machine, grind, or otherwise emove the soft skin at extra expense to obtain the esired property. Best results therefore can be obtained y heating such parts in nondecarburizing atmospheres o that upon quenching they will have hardness at the urface and maximum physical properties. The ability f various commercially available gases to decarburize r avoid decarburizing typical steels ordinarily heated n them for protection will now be considered.

HYDROGEN

Pure dry hydrogen is used for bright-hardening, nnealing, and brazing high-chromium high-carbon teel parts with a minimum of surface decarburization. he work pieces are usually enclosed in metal retorts o assure that the high-purity gas will not be con- aminated by moisture or air entrapped in the furnace rickwork or insulation.

ROPERTIES OF PURE DRY HYDROGEN

The action of hydrogen on steel with respect to de- arburization is dependent upon various factors such as: he hydrogen impurities; the means of preventing ontamination of purified hydrogen as it surrounds the ork within the furnace; the carbon content of the teel; alloying elements, such as chromium in the steel; emperature; and time held at temperature. Conflicting pinions have been expressed regarding the ability of hydrogen to decarburize, but they have undoubtedly been based on variable conditions such as those named.

Recent investigators who have worked with exceptionally pure dry hydrogen are in agreement that, with high purity, it has only slight decarburizing power—in fact, so little under some conditions as to be almost negligible. For example, C. R. Austin(10) reported only slight partial decarburization of 1.1 percent plain carbon steel, heated 55 hr at 1470 F in pure dry hydrogen entering the furnace; an improvement to practically no decarb when increasing the entering dew point to −27 F (10 mg H_2O per cu ft); marked partial decarb with dew point of +5 F (50 mg per cu ft); and complete decarburization of the surface with dew point of +34 F (150 mg per cu ft). His pure dry hydrogen would not tarnish stainless-steel strip at 1290 F for 60 min, which is an index of good purity. Chromium-steel samples (SAE 52100) similarly treated were slightly less affected, which is to be expected because chromium steels are known to have less tendency to decarburize in comparison with plain carbon steels. His test for decarburization was to machine successive peripheral layers from treated round bars, and assay the turnings for carbon.

Likewise, F. C. Kelley(11) reported inability to obtain good wetting on interfaces within joints of 0.35 C and 1.05 C steel test samples that were furnace-brazed in pure dry hydrogen, using inserts of copper foil within the joints. This poor wetting effect was attributed to the lack of affinity of the carbon in the steel for the copper.

In subsequent experiments, preliminary surface decarburizing treatments were found necessary to obtain good wetting. The 0.35 C steel could be partially decarburized in pure dry hydrogen at 1835 F for 15 min to obtain fairly good bonds, but better results in decarburizing were obtained with saturated-line hydrogen at 1925 to 2015 F. The 1.05 C steel was insufficiently decarburized in pure dry hydrogen in 30 min at 1835 F, to obtain good wetting. Better results in this respect were obtained by using saturated-line hydrogen for decarburizing at 1835 F, and then coating the interfaces with nickel nitrate, which further encouraged the

---

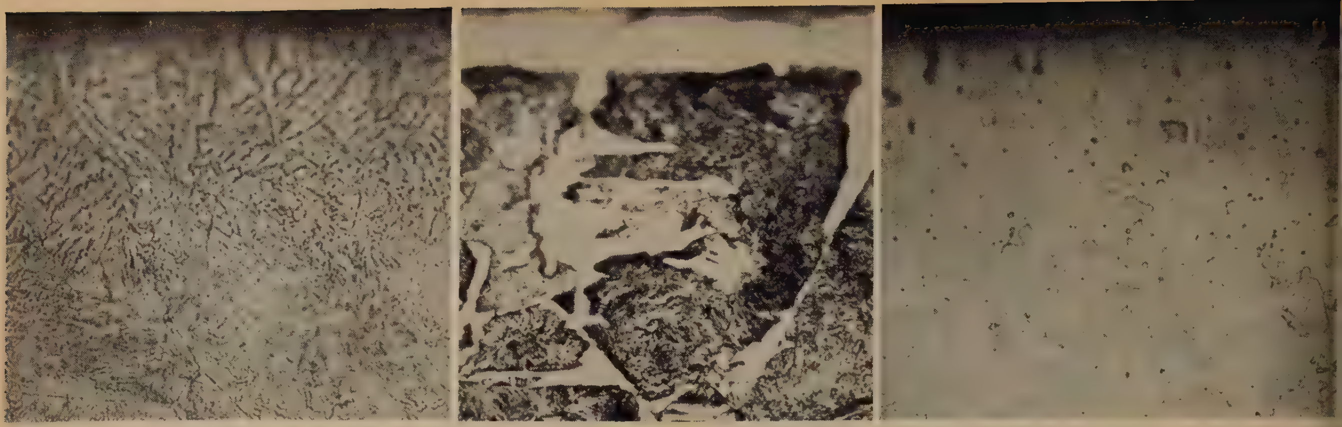
(10) "A Study of the Effect of Water Vapor on the Surface Decarburization of Steel by Hydrogen with Certain Developments in Gas Purification", by C. R. Austin, *Transactions American Soc. for Metals*, vol. 22, pp. 31 to 67, 1934.

(11) "The Effect of the Physical State of Steel Upon the Tensile Strength of Brazed Joints", by F. C. Kelley, *Welding Jour.*, Feb. 1941.

*The following will facilitate the location of material published in earlier parts of this serial:

Part	*Issue*	*Figs.*	*Equations*	*Tables*	*Footnotes*
Part I	Nov. 1948, p. 29	1 to 6	None	I to II	None
Part II	Dec. 1948, p. 41	7 to 14	(1) to (18)	III to IV	(1) to (9)
Part III	Feb. 1949, p. 37	15 to 23	None	V to VI	None
Part IV	Mar. 1949, p. 25	24 to 35	None	VII	None

This article is so paged that without mutilating other articles, it can be eadily removed for filing as a group of full-size consecutive pages.—EDITOR



SAE 4130 SAE 1040 12 Cr -1.5 C

Fig. 36. Photomicrographs (×500) of three different steels treated in pure dry hydrogen. Samples were treated in a metal-sealed welded retort, utilizing the copper-brazing cycle given in Table VIII

wetting. Well-brazed samples were obtained when prepared in this manner, the brazing atmosphere being oxygen-free dry hydrogen with sufficient purity to reduce Cr_2O_3, the well-known green chromium oxide.

Kelley recently treated some small steel test samples in pure dry hydrogen. He carefully weighed them before and after the treatments and measured the surface areas to determine the weight change per unit area, which is a good means of expressing decarburization. The results of his experiment are given in Table VIII. On the basis that the generally acceptable range of weight change is −20 to +50 gr per sq cm × 100,000, all of the samples would be considered excessively decarburized to obtain maximum surface hardness.

Photomicrographs provide another test frequently used for detecting surface decarburization. Those shown in Fig. 36 are taken from a few selected samples in Table VIII. The high-chromium air-hardening and the SAE 4130 steel show no indication of surface decarburization. However, a decrease in surface hardness might be indicated on a superficial tester. The SAE 1040 steel, which registered a weight loss of about the same as the 12 Cr, actually shows a small band of decarburized area about 0.0005 in. thick.

In Part III, attention was called to the influence of impurities in hydrogen, such as hydrocarbons, on the work being treated in the protective atmosphere. This can be illustrated by the production and use of pure dry hydrogen purchased in bottles, made by the catalytic process for converting hydrocarbons. As mentioned in Part III, this hydrogen has possible impurities of carbon monoxide and methane. The gas was purified to remove oxygen and water vapors and then used in 18 Cr-8 Ni retorts with Inconel hydrogen inlet tubes, for bright-hardening and brazing of high-chromium steels. Severe carburizing of both the retorts and inlet tubes was noted.

Fig. 37 is a photomicrograph of a section of thin sheet of 18-8 alloy used as a deflector in front of the hydrogen inlet tube within the box. Starting with very low carbon content, these parts have been found to contain between 4.0 to 5.0 percent carbon after several cycles in the furnace. Fig. 38 is a section of the Inconel hydrogen inlet pipe inside the box. It is carburized on the inside as indicated by the darkened area at the bottom of the photomicrograph, and the carbon penetrates toward the outside surface but not completely to it. The large white grains at the top are on the outside. The carburizing action was most pronounced wherever there was a direct gas impingement on parts from small holes in the inlet pipe. This difficulty was eliminated by changing to dissociated ammonia but it could also have been done by changing to hydrogen made by some other method free from the hydrocarbon and CO impurities.

TABLE VIII

WEIGHT CHANGE OF SAMPLES TREATED IN A PROTECTIVE ATMOSPHERE OF PURE DRY HYDROGEN[*]

Type Steel	Weight Change Gr per Sq Cm × 100,000	Heat Treatment
5 Cr -1.0 C	−28.1	Hardening cycle[†]
12 Cr -1.5 C	−28.4	
5 Cr -1.0 C	−43.5	Copper-brazing cycle[‡]
12 Cr -1.5 C△	−34.3	
SAE 1040△	−34.1	
SAE 1060	−52.7	
SAE 1090	−63.3	
SAE 4130△	−29.7	
SAE 4150	−46.2	
SAE 6140	−57.8	
SAE 52100	−54.9	

[*] The small test samples were treated in a metal-sealed welded retort with gas-inlet tube and with vent hole in the retort for gas outlet, in a tube-type controlled atmosphere furnace. Pure dry hydrogen with −100 F dew point was supplied to the interior of the box, and dried hydrogen atmosphere surrounded the box in the furnace. (The tests were made by F. C. Kelley, Research Laboratory, General Electric Company.)

[†] In the hardening cycle, the samples were put into an 1875 F heating chamber, allowed to come to temperature for 25 min, held at 1875 F for 45 min, and withdrawn to the cooling chamber where they rested two hours.

[‡] In the copper-brazing cycle, the samples were put into a 1950 F heating chamber and allowed to come to temperature for 30 min. Then the temperature was raised to 2000 F in 5 min; the parts were held at 2000 F 18 min, then withdrawn to the cooling chamber where they rested two hours.

△Photomicrograph of this sample, after treatment, is shown in Fig. 36.

NITROGEN

Nitrogen, being inert, would be a good protective atmosphere for preventing surface decarburization except that it lacks self-protection against impurities uch as oxygen, carbon dioxide, and water vapor. These mpurities could enter the furnace with the work, hrough door openings, and from gas-flame curtains at he openings. Small amounts of these impurities will ecarburize the steel being treated. As a result, nitrogen s not commonly used for such applications.

Mixed gases, however, consisting essentially of nitroen with small amounts of carbon monoxide, hydrogen, nd a hydrocarbon, such as propane—added from an uxiliary source—are sometimes utilized. The hydroarbons provide a carburizing action which counteracts he decarburizing action of impurities in the atmosphere. Such an application will be described in Part VI under he heading Combusted Fuel Gas (Purified).

Carbon Dioxide

Carbon dioxide is to be avoided wherever surface decarburization is a factor. It is not used in itself as a protective atmosphere for steels, because it scales and decarburizes them badly. It does appear, however, in some mixed gases, such as low-ratio combusted fuel gas. The reaction of CO_2 with iron carbide is

$$CO_2+Fe_3\,C=3\,Fe+2\,CO \qquad (17)$$

Carbon dioxide will not only decarburize according to this reaction, but it will also combine with hydrogen in mixed gases to form water vapor which, as pointed out, will also decarburize. As a result, CO_2 must be almost entirely removed from mixed gases, along with water vapor, to avoid decarburizing under most conditions.

Dissociated Ammonia

Dissociated ammonia is used as a low-cost substitute for pure dry hydrogen in bright-hardening, annealing, and brazing high-chromium high-carbon stainless steels with minimum decarburization, on short time cycles at fairly high temperatures. Likewise, it is widely used for batch-annealing of coils of high-carbon steel strip, in bell-type furnaces, involving relatively long time cycles and reasonably low temperatures in the neighborhood of 1150 to 1300 F. In all of these applications, the high purity of the gas is maintained by enclosing the work in metal retorts to avoid contamination by water vapor and oxygen entrapped in the furnace brickwork and insulation. In the bell furnaces, the brick load-supporting bases are covered with sheet alloy for this purpose. Oil seals around the bases provide gas-tight closures when the sheet-metal retorts are set down over the charges and engage with the seals.

PROPERTIES OF DISSOCIATED AMMONIA

Dissociated ammonia is free of oxygen and relatively free of water vapor, its dew point being −40 to −60 F. Thus, this mixture of 75 percent hydrogen and 25 percent nitrogen has about the same properties as pure dry hydrogen.

Some small weight-change samples were treated in dry dissociated ammonia, using two different cycles of rather short duration, the results of which are shown in Table IX. The cycles are described in the footnotes set beneath the table. With an acceptable range of −20 to +50 gr per sq cm×100,000, seven of the samples fall within the range and three outside, selected for the ability to give maximum hardness at the surface as well as in the core. (Tests were made by John Grodrian.)

Fig. 39 shows a photomicrograph of the SAE 1040 steel after the treatment indicated in Table IX. The

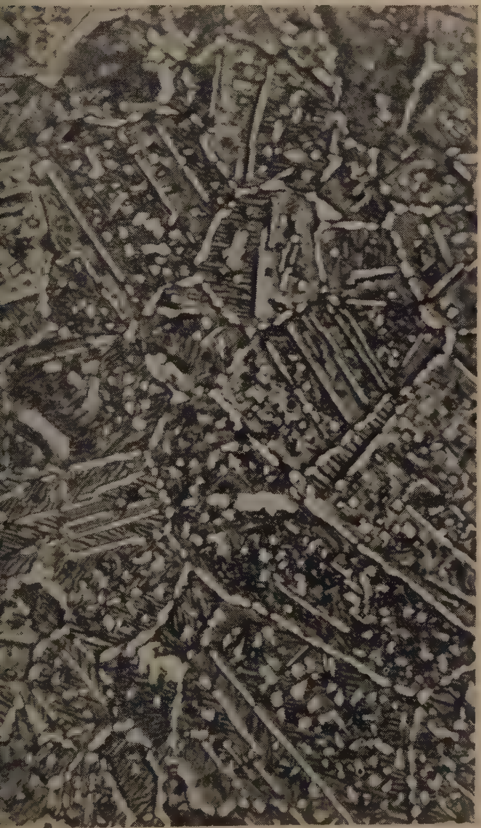


Fig. 37. Photomicrograph (×500) of carburization throughout a thin sheet of 18–8 alloy, attributed to carbon monoxide and methane impurities in otherwise pure dry hydrogen, during repeated heating at 1875 to 2005 F

(*Photomicrographs by John Grodrian*)

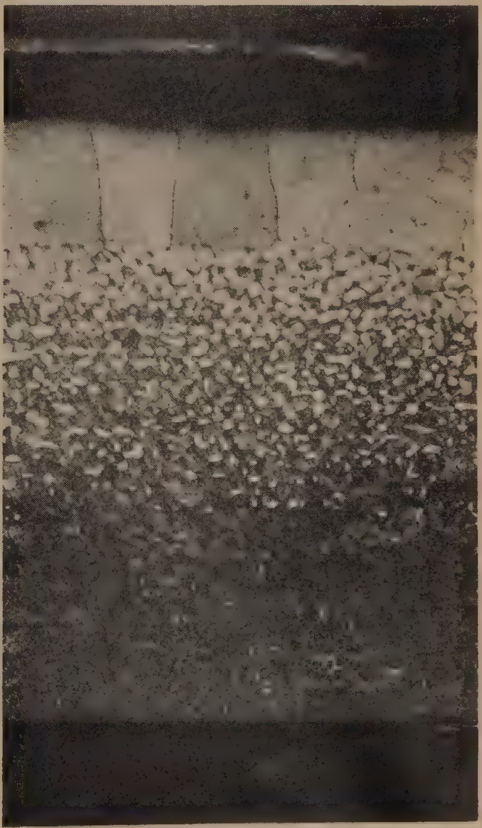


Fig. 38. Photomicrograph (×35) of section of Inconel tubing showing carburization (darkened grains at bottom) of inside of tube carrying supposedly pure dry hydrogen at 1875 to 2005 F

decarburization is so slight that it is not evident at the surface of the sample. This photomicrograph compared to that of the SAE-1040 sample in Fig. 36 indicates the range in weight loss where decarburization can be found by microscopic examination.

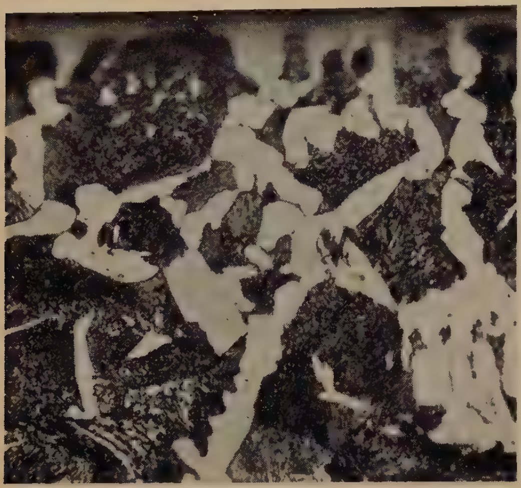
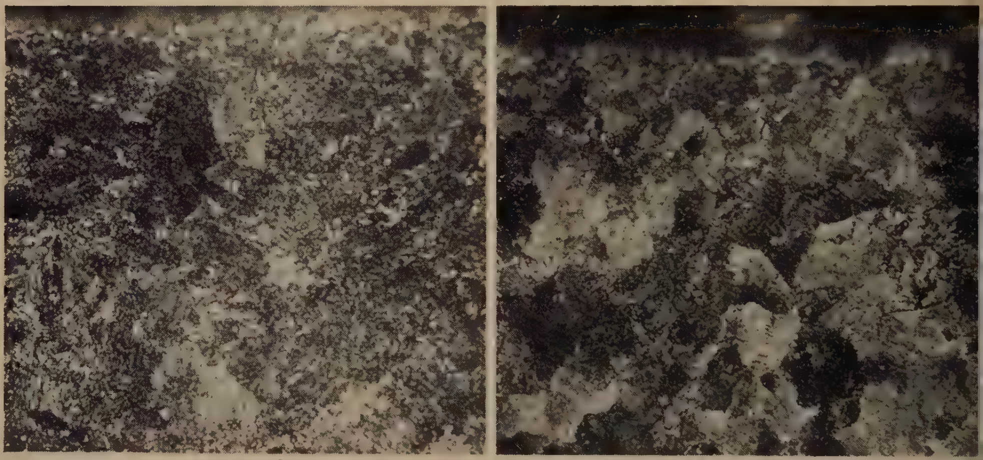


Fig. 39. Photomicrograph (×500) of SAE 1040 steel treated in dry dissociated ammonia. Sample enclosed in an alundum-sealed retort, utilizing the copper-brazing cycle given in Table IX

Fig. 40. Photomicrographs (×500) of steel samples treated in a commercial bell-type furnace in dissociated ammonia atmosphere. The samples were brought to 1150 F with a full-size load of coiled strip and held at this temperature for 8 hr (see Table X)



SAE 1090

SAE 52100

TABLE IX

WEIGHT CHANGE OF SAMPLES TREATED IN A PROTECTIVE ATMOSPHERE OF DRIED DISSOCIATED AMMONIA*

Type Steel	Weight Change Gr per Sq Cm × 100,000	Heat Treatment
5 Cr -1.0 C	− 7.8	Hardening cycle†
12 Cr -1.5 C	− 1.6	
5 Cr -1.0 C	−29.7	Copper-brazing cycle‡
12 Cr -1.5 C	−18.6	
SAE 1040△	−14.9	
SAE 1060	−22.3	
SAE 1090	−43.4	
SAE 4130	−10.0	
SAE 4150	−17.1	
SAE 6140	−11.2	

*The small test samples were treated in an alundum-sealed retort with gas-tube inlet and outlet, in a box-type controlled atmosphere furnace. Dried dissociated ammonia at a dew point of −70 F was supplied to the interior of the box, and catalytically reacted fuel-gas atmosphere similar to Item F1a in Table I surrounded the box in the furnace. A sample of the atmosphere leaving the retort tested −38 F dew point. (The tests were made by John Grodrian, Bendix Products Division, Bendix Aviation Corporation, South Bend, Indiana.)

†In the hardening cycle, the samples were put into an 1885 F heating chamber, allowed to come to temperature for 25 min, held at 1875 F for 45 min, and withdrawn to the cooling chamber where they rested two hours.

‡In the copper-brazing cycle, the samples were put into a 1950 F heating chamber and allowed to come to temperature for 28 min. Then the temperature was raised to 2005 F in 3 min; the parts were held at 2005 F for 23 min, cooled to 1850 F in 12 min, then withdrawn to the cooling chamber where they rested two hours.

△Photomicrograph of this sample, after heat treatment, is shown in Fig. 39.

TABLE X

WEIGHT CHANGE OF SAMPLES TREATED IN A PROTECTIVE ATMOSPHERE OF DISSOCIATED AMMONIA

Type Steel	Weight Change Gr per Sq Cm × 100,000	Heat Treatment
SAE 1040	−10.2	Bell-furnace Annealing
SAE 1060	− 7.1	
SAE 1090△	− 8.5	
SAE 52100△	−10.2	

The small test samples were treated with a regular load of carbon-steel strip in coils in a bell-type furnace with metal-covered base and oil-sealed metal retort. The load was heated to 1150 F, held 8 hr, and cooled at normal rate in the retort with the furnace lifted off. The dissociated ammonia was not dried, and entered the furnace with a dew point of about −40 F.

△Photomicrograph of this sample, after treatment, is shown in Fig. 40.

At lower temperatures, dissociated ammonia has even less decarburizing action even at longer times. This is illustrated by Table X, which gives the results in weight change on four different types of steel annealed in a bell-type furnace held at 1150 F for eight hours. The weight loss is well within the acceptable range of −20 to +50 gr per sq cm ×100,000, indicating negligible decarburization.

Fig. 41. Photomicrograph (×500) of a sample of steel strip cut from a coil annealed in dissociated ammonia at 1150 F for 8 hr (see Table X)

Photomicrographs of selected samples from Table X are shown in Fig. 40 illustrating that the decarburization is negligible.

The SAE 1090 steel has at some spots a thin, partially decarburized band of about 0.0001 in. Fig. 41 shows a sample of strip cut from the large coils annealed in the same cycle. There is no evidence of decarburization on this sample.

(*To be continued*)

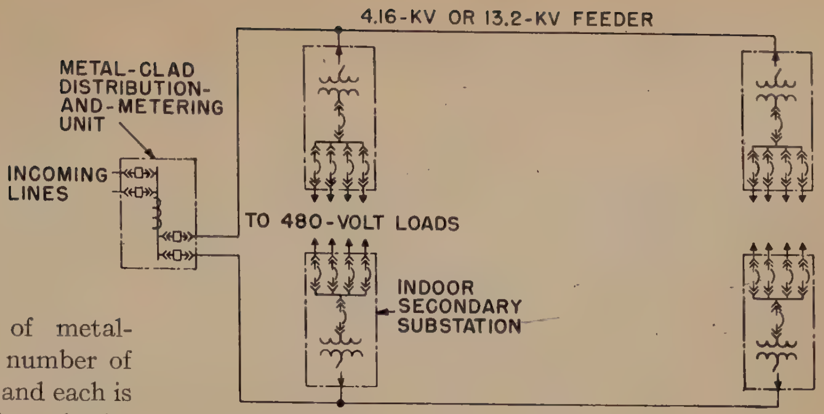

4.16-KV OR 13.2-KV FEEDER
METAL-CLAD DISTRIBUTION-AND-METERING UNIT
INCOMING LINES
TO 480-VOLT LOADS
INDOOR SECONDARY SUBSTATION

Fig. 18. Radial system for industrial application has low first cost

The outgoing feeder section consists of metal-nclosed low-voltage switchgear. Usually a number of eeder circuits are connected to a substation and each is ontrolled and protected by a circuit breaker of adeuate interrupting capacity.

The breakers may be either manually or electrically perated, the manually operated being used in the najority of the applications. For network applications, he standard network protector replaces the main econdary breaker in the low-voltage switchgear.

The highest-voltage class at which power may be arried indoors to the load area is 15 kv. It is usually neconomical to carry power to the work areas at less han 2400 volts. Thus, for a given application, any one f the standard voltages between 2400 and 13,800 may e selected, the selection depending on local conditions nd the requirements to be met.

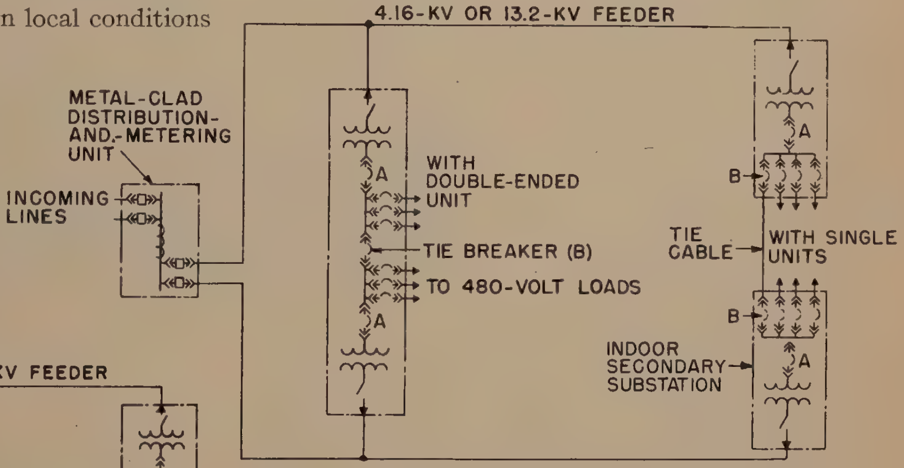
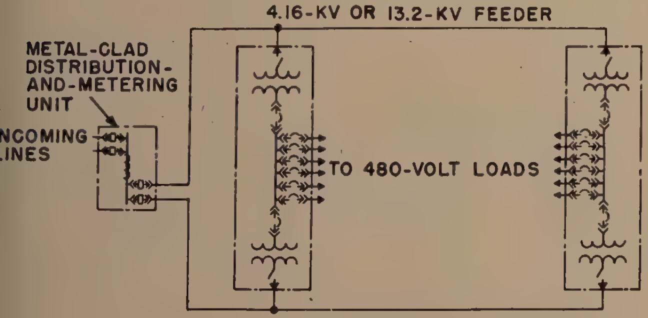


Fig. 19. Secondary-selective system for industrial application gives service continuity with only brief interruption on load transfer

ig. 20. Spot-network system for industrial aplication gives continuity with no service interuption with transfer of load


4.16-KV OR 13.2-KV FEEDER
METAL-CLAD DISTRIBUTION-AND-METERING UNIT
NCOMING LINES
TO 480-VOLT LOADS

The power is stepped down to utilization voltage at he work area. Of the several voltages available, amely, 600, 480, 240, and 208/120, 480 volts is the one sed the most for power and 208/120 volts for lighting nd small power tools.

Placing the substation in the work area results in the ost economical system because it is less expensive to istribute power at high voltage than at low voltage. Small substations permit the use of smaller secondary ircuit breakers which are less expensive yet have dequate interrupting capacity. Another important dvantage is that the voltage regulation is kept to reasonble limits.

LOAD-CENTER UNIT SUBSTATIONS: INDUSTRIAL APPLICATIONS

Experience in the design and application of industrial plant distribution systems has shown that the four most acceptable types are:

(1). Radial (Fig. 18)
(2). Secondary selective (Fig. 19)
(3). Spot-network (Fig. 20)
(4). Low-voltage network (Fig. 21)

Radial System

The radial system has one high-voltage feeder protected by a power circuit breaker, usually located near the circuit entrance to the plant. This circuit feeds one or more radial-type substations as shown in Fig. 18.

This type of system, when properly applied, has the lowest first cost, and it is widely used. With the present-day reliability of standard unit substations, cables, etc., failures in this type of system are very infrequent. There are some cases, however, where even a short interruption can mean a costly manufacturing shutdown; for this service, one of the other types of distribution systems will prove to be more applicable.

Secondary Selective System

The secondary selective system has two high-voltage feeders protected by power breakers which feed pairs of distribution substations arranged for emergency interconnection of their secondaries as shown in Fig. 19. A

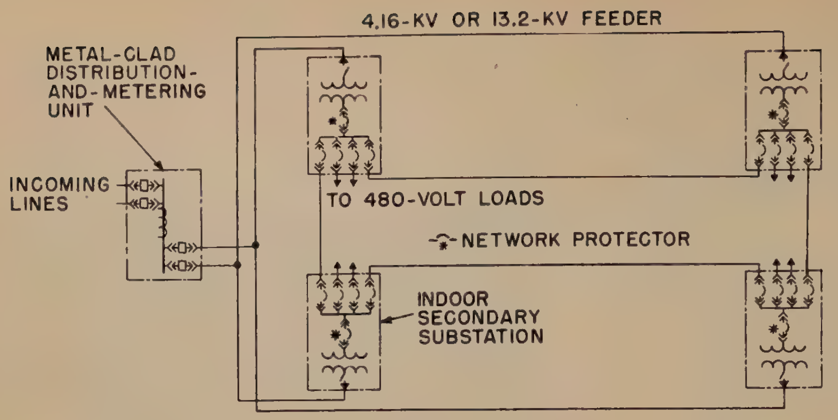

4.16-KV OR 13.2-KV FEEDER
METAL-CLAD DISTRIBUTION-AND-METERING UNIT
INCOMING LINES
TO 480-VOLT LOADS
NETWORK PROTECTOR
INDOOR SECONDARY SUBSTATION

Fig. 21. Low-voltage network system has limited applicability for industrial use, although it gives highest degree of service continuity because of automatic isolating of faults

double-ended unit substation, as shown on the left, or two single-ended substations, as shown on the right, may be used.

For normal operation, the tie circuits are open and each transformer carriers the portion of the load assigned to it.

For emergency operation when one feeder is out of service, the other feeder and the substations connected to it carry the plant load.

To transfer the load, the main breaker *A* of the deenergized transformer is opened and the normally open tie breaker *B* is closed. These breakers are interlocked so that when the tie breaker *B* is closed only one of the main breakers *A* can be closed. This interlocking is necessary to limit the short-circuit duty on the secondary feeder breakers because, if the transformers could be paralleled, the short-circuit current would be doubled and larger and more expensive breakers would be required.

The transfer of load may be manual or automatic.

The secondary selective system insures service continuity with only a short interruption while load is being transferred in the event of trouble in either a substation transformer or primary feeder cable and is thus a more reliable system than the straight radial type. Because of the duplication of equipment it can be more costly than the straight radial, but if no reserve transformer capacity is installed it may be only slightly more expensive.

Spot-network System

The spot-network system has two high-voltage feeders protected by power breakers. These serve double-ended substations which are normally paralleled on their secondaries as shown in Fig. 20. This system differs from the low-voltage selective system in that there are no normally open tie breakers between pairs of transformers.

In the event of a high-voltage cable failure, the main secondary breaker opens automatically on the transformer to be de-energized and the substation load is carried on the remaining transformer. With this transfer of load, there is not even a momentary service interruption. This type of system is applicable to those plants with special manufacturing processes where even a momentary power interruption means a costly shutdown.

The spot-network system requires duplicate high-voltage feeders, two transformers with sufficient reserve capacity for each one to carry the entire load continuously and secondary breakers of approximately double interrupting capacity of a single-transformer substation, which are all costly items. The use of the system, however, does assure service continuity.

Low-voltage Network System

The low-voltage network system has two or more high-voltage feeders protected by power breakers serving low-voltage network substations as shown in Fig. 21. The low-voltage feeders of all of the substations are solidly interconnected to form a grid. Trouble in any high-voltage feeder or transformer is automatically isolated by the high-voltage breakers and the associated low-voltage network protectors, permitting the load to be carried by the remaining substations serving the grid.

When properly applied and maintained, the low-voltage network system has the highest degree of

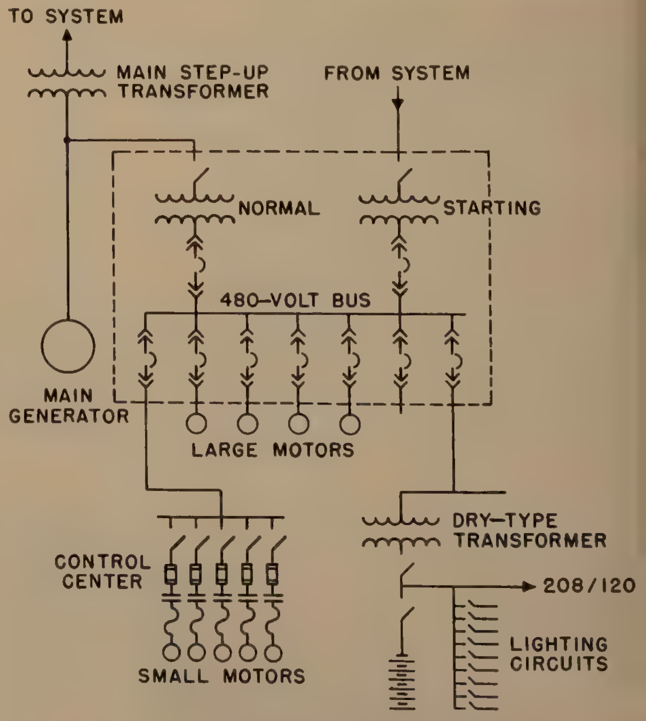


Fig. 22. Power-generating-plant auxiliary system

rvice continuity because high-voltage faults are tomatically isolated without a service interruption. owever, for troubles in the low-voltage circuits, its liability is no greater than that of any of the pre-ously discussed systems.

This system has the highest cost of all. Transformer serve capacity is required, and low-voltage short-rcuit currents are at the maximum, requiring more stly breakers. Low-voltage tie circuit capacity which ust be provided increases the cost.

The low-voltage network system has had only latively limited application to industrial power sys-ms because of its high original first cost and more volved maintenance, because the network protectors quire much more than the normal skill to service.

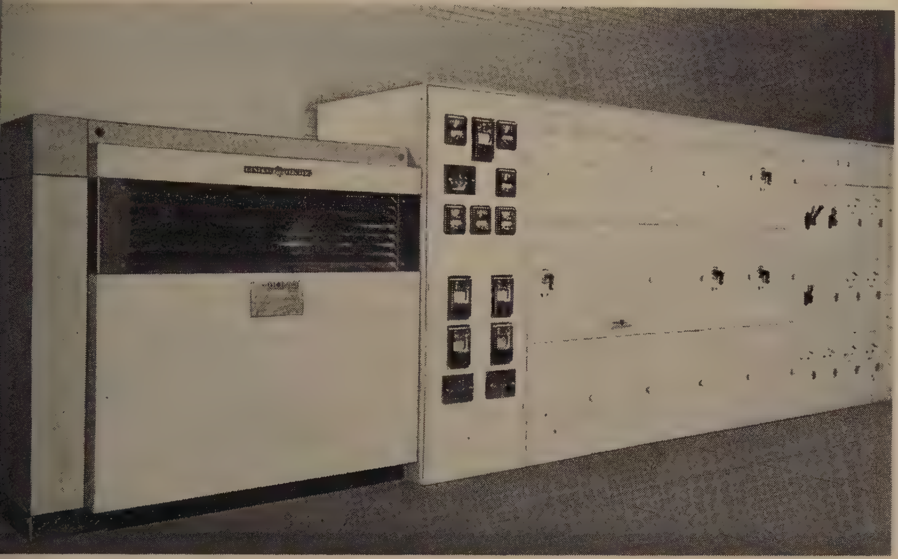


Fig. 23. Load-center unit substation for generating-plant auxiliaries

OAD-CENTER UNIT SUBSTATIONS: CENTRAL-STATION PPLICATIONS

The majority of the central-station applications of ad-center unit substations are in the power supply ystems for the auxiliaries of power generating plants. hese auxiliaries are almost exclusively a-c motor riven and include such items as fuel-handling equip-ent, forced- and induced-draft fans, feed-water umps, machine shop, etc. requiring a few large motors nd many small ones.

The reliability of a power plant can be no better than e reliability of its auxiliaries and thus the power pply for these auxiliaries is one of the most important ems in the plant design.

A separate power-supply system for each boiler is nerally considered to be the best practice. If two ilers are used to supply one turbine, two complete d independent systems would be used.

Of the various possible sources of power available, at obtained from the main generator leads usually oves to be the most desirable. An alternate source of wer is also necessary to start the auxiliaries before e turbine can be started and this is obtained from a cond transformer from the main power system as own in Fig. 22.

The 480-volt system is generally considered the standard as this voltage is conservatively low and motors and control at this voltage are widely used and generally available.

If the total boiler load in kva requires a transformer rating of 1000 kva or less, the 480-volt system is applicable because motors as large as 250 hp are available at this voltage. Boilers requiring transformer capacity of 1500 kva or more usually require a higher voltage, namely, 2400 volts for the larger motors. In the latter case a two-voltage system, namely, 2400 volts and 480 volts, would be used with the 480-volt system feed from the 2400-volt bus.

The reliability of present-day unit substations justifies the single-bus low-voltage selective system. The best plan is to keep the low-voltage cables as short as possible, and the short-circuit currents to the minimum.

Lighting may be obtained from a 480-volt lighting feeder by the use of small single-phase transformers. A small amount of emergency lighting is available from the station battery.

A distribution substation for supplying some of the auxiliaries in a power plant is shown in Fig. 23. This substation consists of a 750-kva dry-type unit having 480-volt drawout breakers and combination motor starters.

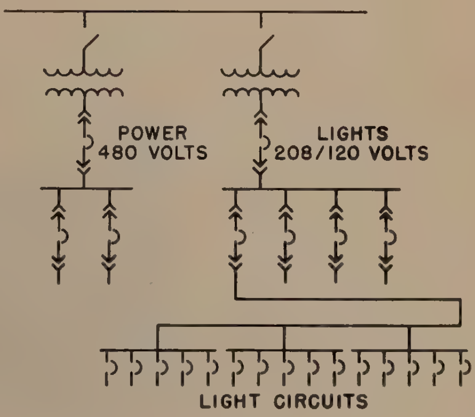


Fig. 24 Separate lighting and power substations, suitable for large plant

METHODS OF PROVIDING PLANT LIGHTING

There are three standard methods of supplying power for lighting in industrial plants, generating plants, and commercial buildings.

In a large plant, individual, factory-assembled lighting substations of the proper kva size may be installed as shown in Fig. 24. If this is done, the power and lighting substations are separated and light flicker is minimized. This method may prove to be mor expensive than other means that are available, especiall for smaller plants.

For small plants, the power and lighting circuits ma be brought to a 480-volt substation and small dry-typ transformers located out in the plant; these are used fo stepping down the voltage from 480 volts to the lightin voltage as shown in Fig. 25. With separate lighting an power feeders, load fluctuations do not appreciabl change the light intensity. However, combined powe and lighting substations are usually not acceptable i the power load consists of resistance welders.

Fluorescent lighting fixtures are available for 480/277 volt circuits. Accordingly, a third method of providin lighting is to have the power transformers connecte for 480 Y volts grounded. The fluorescent lights ar switched on and off in blocks of 10 to 15 kva by the us of motor starting contactors. This arrangement i shown in Fig. 26. The necessary 208/120 volts for smal power tools, etc., may be obtained from suitabl located small dry-type transformers in the work area

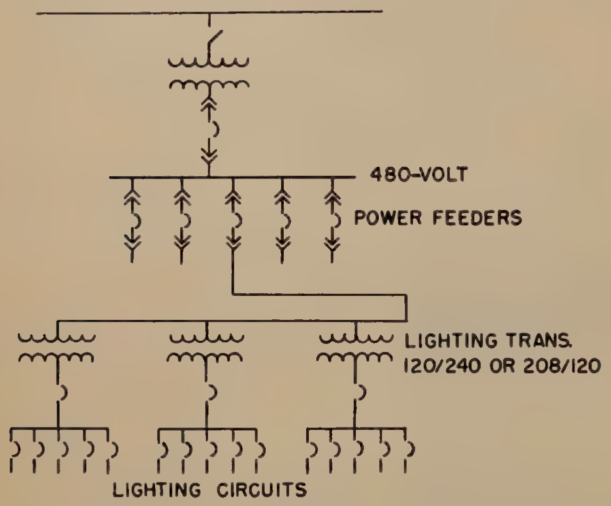


Fig. 25. Small lighting transformers supplied by 480-volt substation, for small plant

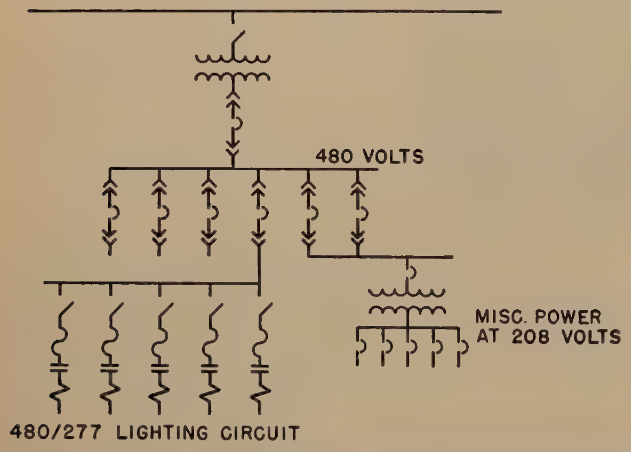


Fig. 26. Combined power and lighting on one substation using 480/277-volt service accommodates fluorescent lighting

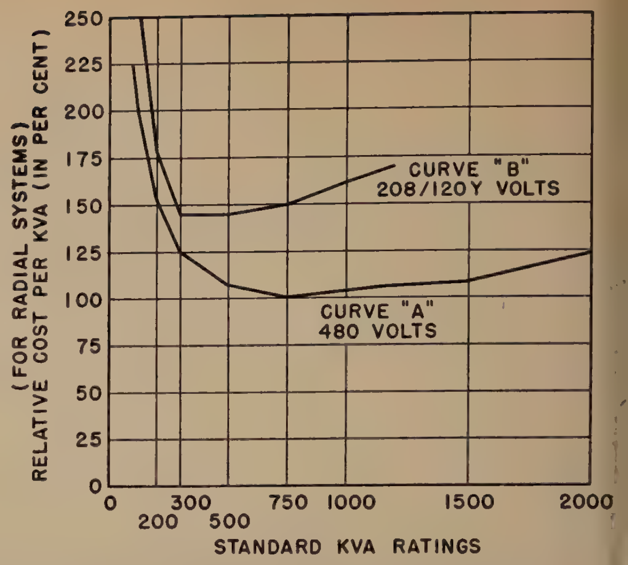


Fig. 27. Relative costs of various unit substations

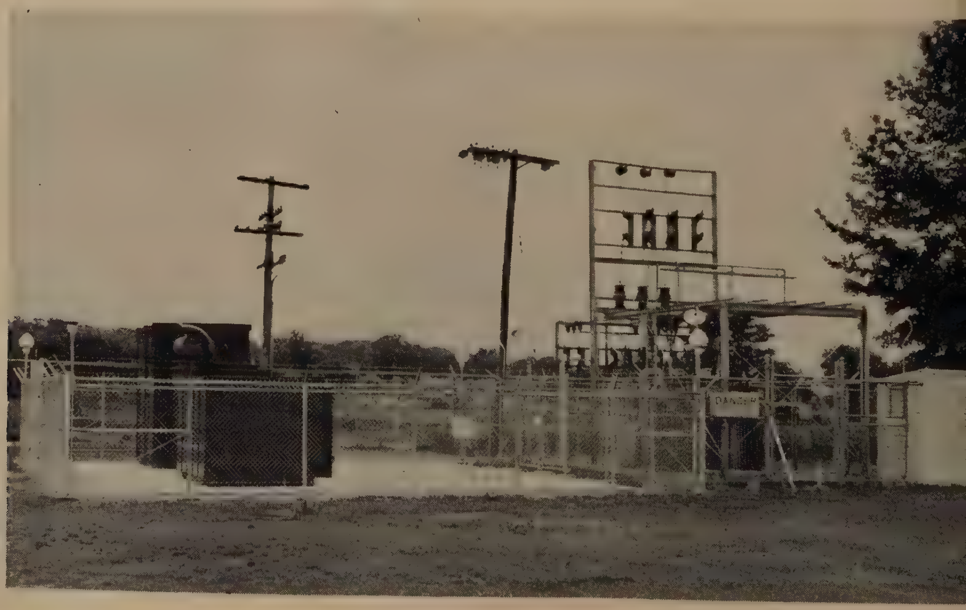


Fig. 28. Cost comparison of 1000-kva substations. Factory-assembled (at left), $18,610; field-assembled (at right), $22,314

OAD CENTER UNIT SUBSTATIONS: ECONOMICS OF SUB- ATION SIZES

In designing a low-voltage distribution system, the west cost is obtained by studying the cost of all the mponent parts. The largest item of cost is the subation. The larger the kva size of the substation, the wer the cost per kva of the transformer; but this wer cost is usually offset by the higher cost of the itchgear, because of the increased interrupting pacity required on the low-voltage breakers. The sign must therefore be a balance between the cost of e high-voltage switchgear and cable, the substation, d the low-voltage feeder cables.

Each individual application should be studied cause usually there will be special requirements that ust be factored. As a general guide to this problem, lative cost per substation kva for various standard va sizes and voltages is given in FIG. 27. The curves ow the most economical size of substation for condary voltages of 480 and 208/120.

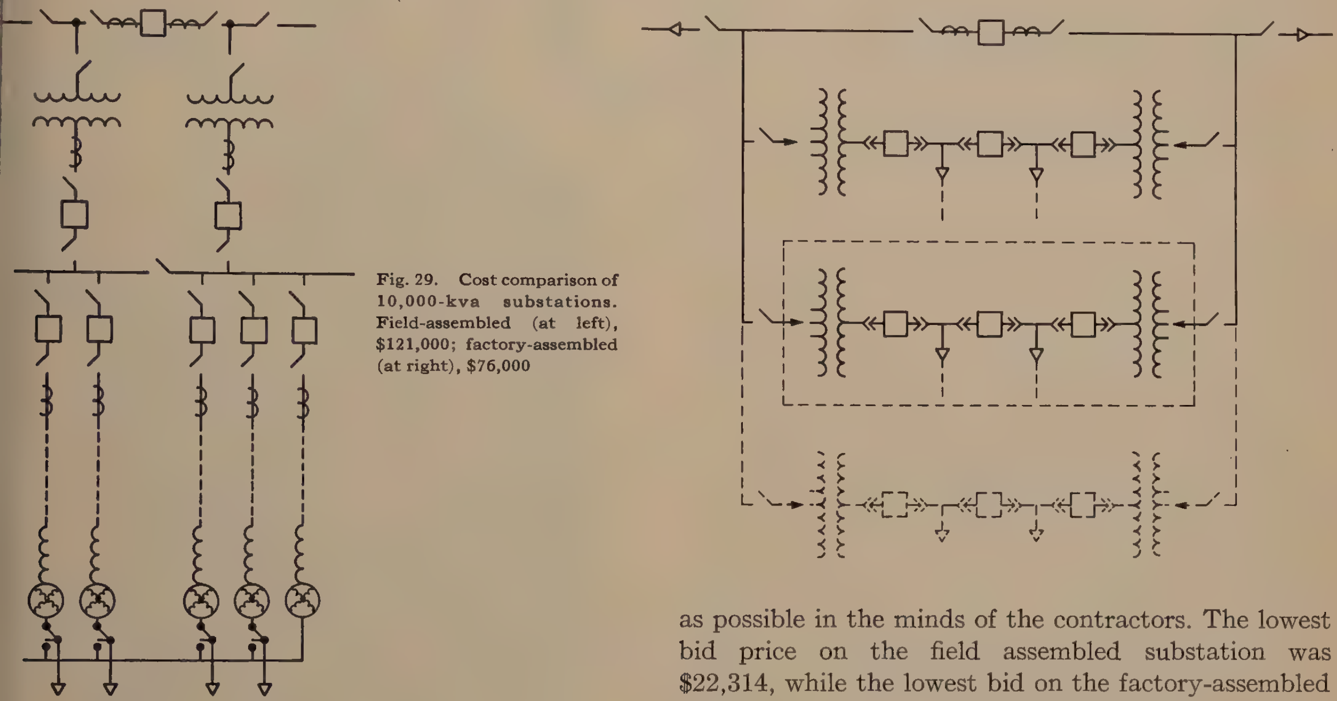


Fig. 29. Cost comparison of 10,000-kva substations. Field-assembled (at left), $121,000; factory-assembled (at right), $76,000

Cost Comparisons

The use of standardized factory-assembled substations get the lowest over-all system investment has already ceived unusually rapid acceptance. Undoubtedly, this as accelerated greatly by the war, but the even greater end in this direction since the war indicates that ere must be a reasonably firm basis for this change. IG. 1 illustrated graphically the number of factory-sembled substations in service at the end of each year, us showing how this acceptance has gone forward.

One of the strongest factors in favor of standardized ctory-assembled substations in their low cost. This due primarily to the tooling and the mass-production ethods which are made possible by standardization. he saving in over-all installed cost is shown by several actual installation comparisons on various size substations. It will be noted that the savings average from 15 percent to 35 percent on a total-installed-cost basis.

In the case shown in FIG. 28, eleven electrical contractors bid on duplicating exactly the substation shown in the righthand side of the photograph. The contractors were also asked to bid alternatively on a functionally equal factory-assembled substation, thus providing an excellent comparison between the actual over-all installed costs of the two jobs. Each contractor was interested in bidding the job as low as he could in order to receive the award of the contract. On the other hand, each contractor wanted his price high enough so that he would get a fair profit. These two reactions naturally forced the bid price to be as representative of real costs as possible in the minds of the contractors. The lowest bid price on the field assembled substation was $22,314, while the lowest bid on the factory-assembled substation, completely installed and ready to operate was $18,610—a saving of $3704 or over 16 percent. The factory-assembled substation was purchased and installed, as shown on the lefthand side of the photograph, because of lower cost, greater safety to personnel, and better appearance.

A cost comparison illustrating a 10,000-kva substation is given in FIG. 29. It will be noted that these one-line diagrams are typical of medium-sized substations. The substation shown on the left was field-assembled of good-quality equipment. The factory-assembled substation that is shown on the right has an entirely different one-line diagram, but provides exactly the same functions and output ratings as the other. The saving of $45,000, or over 37 percent, is not uncommon. This comparison also indicates another important point about standardization. Quite often it is necessary to review the application carefully, and change the exact arrangement considerably in order to bring out the greatest saving in the use of standard units. As indicated here, by altering the one-line diagram to an arrangement that would use duplex

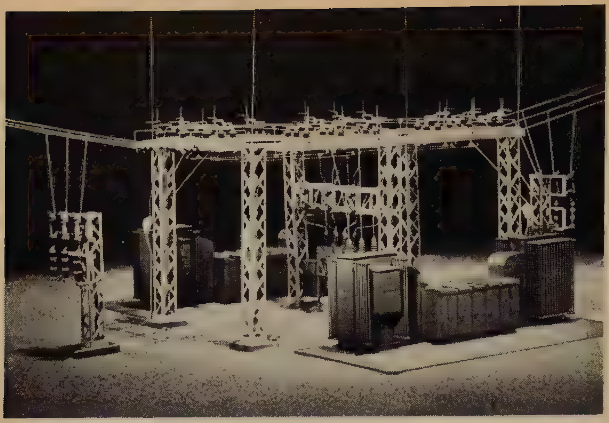


Fig. 30. Factory-assembled duplex substation corresponding to one-line diagram shown at right in Fig. 29

substations, all of the original functions were maintained and yet tremendous savings were made possible.

The example illustrated in Fig. 31 shows a very large distribution substation of a type used in large cities to step down from a backbone system of, in this case, 66 kv to a subtransmission voltage of 13.8 kv. Here, two factors contribute to the savings shown in the example. One is the savings due to standardized factory-assembled substations, and the other is the use of the relatively new high-velocity fan-cooled transformer instead of the older low-velocity fan-cooled transformer. Both types of transformers, with the fans running, have a hottest-spot temperature rise of 65 C at rated load. The use of these high-velocity fans is economical and should be considered for substations requiring two or more transformers where the individual transformers are each over 10,000 kva.

It will be noted that, in addition to the cost saving afforded by standardized factory-assembled substations in this case, they also provide an added safety factor in the elimination of the conventional type of transfer bus. In the factory-assembled unit, breaker bypassing is accomplished by means of a spare power circuit breaker element in such a manner that a mis
operation in bypassing will cause no serious difficulty

Summary

As systems expand, it is frequently the case tha
either more costly, nonstandard equipment must b
continually purchased, or large sums of money spent t
change existing nonstandard equipment to standard
This is usually the result of lack of an adequate pla
for growth and lack of the proper consideration o
apparatus standards in early planning stages.

The foregoing description of standard factory-assembled substations has shown that

(1). There are three basic types of subtransmission systems: radial; multiple; and loop

(2). There are five standard basic types o
package substations: radial; low-voltage selective
primary network; spot-network; and duplex

(3). There are four basic types of industrial plant distribution systems: radial; low-voltage selective; spot network; and low-voltage network

(4). There are four standard basic types of load-center unit substations: radial; secondary selective; spot network; and low-voltage network

(5). Standard factory-assembled substations may be applied to electric-utility systems or industrial systems

(6). They may be used to supply power and lighting in industrial plants or auxiliary power i
generating stations

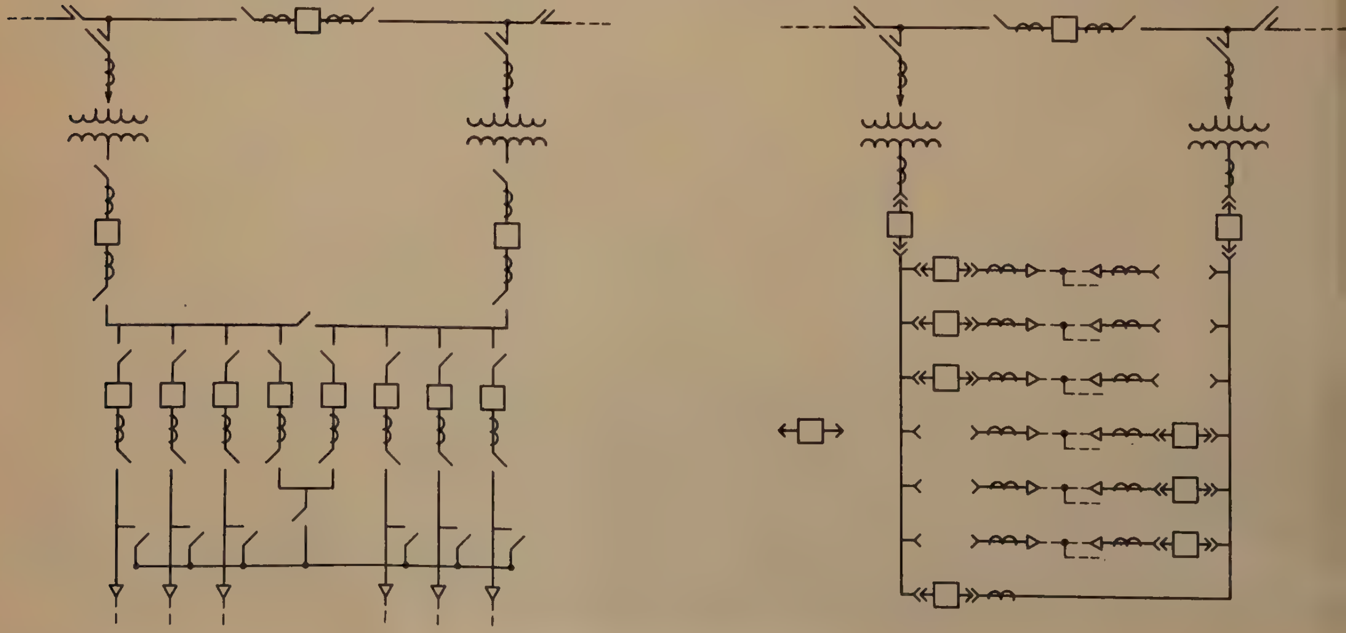
(7). They may be installed indoors or outdoors

(8). The few simple, standardized components may be combined to provide an infinite variety o
substations

(9). Adherence to these existing standards facilitates system planning, procurement, and installation of substation equipment.

(Concluded)

Fig. 31. Cost comparison of 50,000-kva substations. Field-assembled (at left), $303,000; factory-assembled (at right), $239,000



Speer carbon brushes

REFLECT

A Vast Accumulation of Performance Data

A half-century of experience analyzing local conditions influencing carbon brush performance, and the development of brush grades to eliminate specific difficulties, account for a vast accumulation of data at Speer Carbon Company laboratories.

Here, case histories and modern experimental and testing facilities are available for the analysis of your problems, whether they pertain to electric motor brush design, or maintenance. Write for the brush data sheet, shown below, for use in submitting your particular problem.

BRUSH DATA SHEET

GENERAL

Company................................Address................................
Location of Machine and Identifying No.................Brush Blue Print No...............
Recommendation...................Submitted by.................Date...............

DATA ON MACHINE

Motor, Generator or Rotary...................Built by.................................
Used for what service..
Type...............Form...................Serial.................Kv-a. or H. P.........
AC or DC...........Voltage...................Cycles.................Phase...............
R.P.M.............No. of main poles....Do main poles have compensating windings?.........
No. of interpoles........Are they series, shunt, compound or separately excited?...............
Rated load in amps..........................Average load in amps........................
Maximum load in amps........................Duration of maximum load....................
Does machine run in one direction only?...
Do DC Brushes run radial, leading or trailing?..........
Do AC Brushes run radial, leading or trailing?..........

Commutator Diameter.......................
Commutator No. of segments.......................
Commutator Flush or undercut mica.........
Rings Diameter...................................
Rings Number.......................................
Rings Material.......................................
Number of brushes per set, AC.........DC.........Spring pressure DC.....................
Grade of brush now in use, AC.........DC.........Spring pressure AC.....................
Are present brushes satisfactory?.............If not give details.........................
....
....
....
Do brushes spark, glow, squeal or squeak?...
Do brush faces show high polish, copper spots, etc.?......................................
Is commutator or rings burned, roughened, worn or discolored?.............................
Is there evidence of high mica?...
Are there flat spots?...
What grade or grades of brushes have worked successfully?.................................
Remarks:..
....

Speer
CARBON COMPANY
ST. MARYS, PENNA.

brushes · contacts · welding electrodes · graphite anodes · rheostat discs · packing rings · carbon parts

CHICAGO · CLEVELAND · DETROIT · MILWAUKEE · NEW YORK · PITTSBURGH

DEW-POINT RECORDER

An electronic device for the continuous measurement and control of the moisture content of gases and protective atmospheres. Requirements for accuracy and convenience in such operations are increasingly important in industry

By S. S. STACK

General Engineering and Consulting Laboratory
General Electric Company

Sydney S. Stack

MEASUREMENT and control of the amount of moisture in gases and protective atmospheres is of increasing importance in many industrial processes. While the dew-point indicator⁽¹⁾ serves its purpose well as a portable instrument for spot checking, it does not provide continuous indication and recording, which are now necessary in many applications.

The dew-point recorder, shown in Fig. 1, was developed to meet these additional requirements. By means of electronic control, self-balancing is obtained and thus a continuous record of the dew point, or saturation temperature, is obtained. Moisture content can then be determined directly from psychrometric tables or charts.

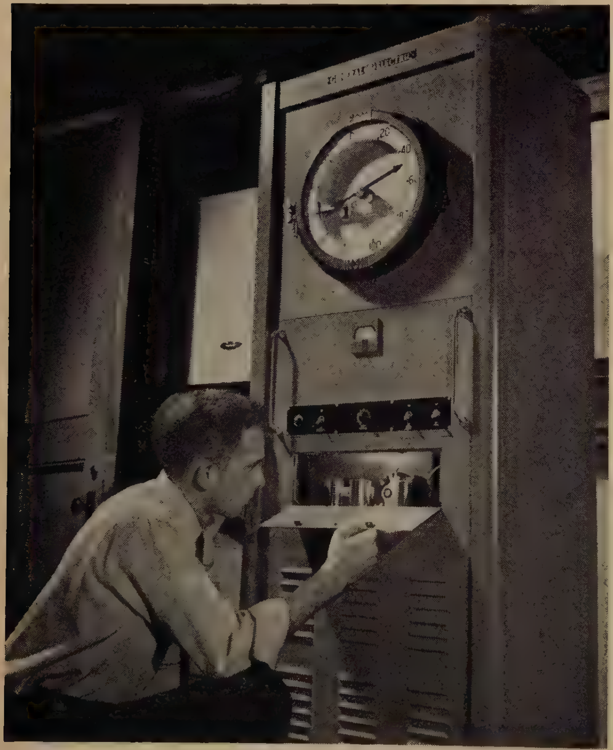


Fig. 1. The dew-point recorder, a fully automatic device for measuring the moisture content of gases, being observed in operation

A small quantity of the gas to be measured is caused to flow through the gas chamber of the recorder, where

---

(1)Numbered references are listed at the end of the article.

This article is so paged that without mutilating other articles, it can be readily removed for filing as a group of full-size consecutive pages.—Editor

TABLE I

Relation between Dew Point and Moisture Content of Gases

With a known dew-point temperature, which is indicated b the dew-point indicator or recorder, the moisture content can b read directly from the table.

The table shows the amount of water vapor in air or other ga *at various dew-point temperatures, and at a pressure of one atmos phere* (14.7 psi).

Dew-point Temp F	Moisture Content		
	Lb per 1000 Cu Ft	Milligrams per Liter	Grains pe Lb Dry Ai
100	2.86	45.6	302
95	2.48	39.7	257
90	2.14	34.3	218
85	1.84	29.6	185
80	1.58	25.3	156
75	1.35	21.7	132
70	1.15	18.4	111
65	0.98	15.7	92.8
60	.83	13.3	77.5
55	.701	11.3	64.6
50	.589	9.5	53.6
45	.493	7.91	44.3
40	.410	6.58	36.5
35	.341	5.47	29.9
30	.280	4.50	24.3
25	.230	3.70	19.8
20	.189	3.02	16.0
15	.154	2.45	12.9
10	.124	1.99	10.30
5	.100	1.61	8.23
0	.081	1.30	6.52
−5	.0641	1.03	5.14
−10	.0508	0.815	4.03
−15	.0400	.642	3.14
−20	.0314	.505	2.43
−25	.0244	.391	1.87
−30	.0189	.303	1.43
−35	.0145	.232	1.08
−40	.0110	.177	0.816
−45	.0083	.134	.610
−50	.0063	.101	.453
−55	.0047	.075	.333
−60	.0034	.054	.243
−65	.0025	.040	.176
−70	.0018	.029	.126
−75	.0013	.021	.090
−80	.0009	.014	.063
−85	.0007	.011	.044
−90	.0005	.008	.030
−95	.0003	.005	.021
−100	.0002	.003	.014

is brought into contact with the face of a metallic rror to which a thermocouple is attached. Means e provided for cooling and for heating this mirror and o for automatically maintaining it at the dew-point mperature of the gas; a temperature recorder is inided to give a continuous record of the temperature the mirror.

VANTAGES OF THE DEW-POINT METHOD

The dew-point method has many advantages over her common methods of measurement. The prinple(2) is well known and provides a convenient means accurately determining the moisture content of ceptionally dry gases, as a nearly linear relation ists, throughout the range, for the percent change in isture content per degree change in dew point. As ble I indicates, there is a decrease of approximately percent for each 15-degree-F decrease in dew point.

In industrial processes the absolute humidity, or nsity of water vapor, is of prime importance. This n be determined directly from the dew-point temrature, so that the ambient (or differential) temrature is not required, as is necessary with other ethods or in relative humidity measurements.

The dew-point method provides a means whereby a mple of the gas to be measured can be brought out d passed through a test chamber where measureents can be made without being affected by velocity, essure, or other sources of disturbance in the system.

A high speed of response is obtainable for recording pidly changing conditions.

SCRIPTION

FIG. 2 is a schematic diagram showing the general inciple of operation and major components employed the dew-point recorder. The equipment is enclosed a floor-mounted cabinet and operates from a 115-lt 60-cycle power supply. The only other connections at are necessary are the inlet and outlet connections to the source of gas to be measured. The temperature recorder's range of −100 to +100 F allows measurement of gases having dew points ranging from −90 F to ambient.

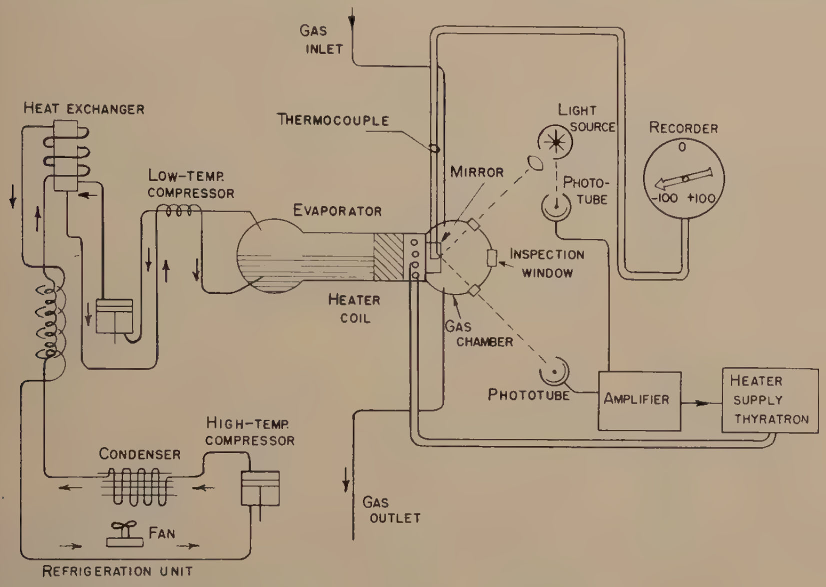


Fig. 2. Schematic diagram of the general principle of operation of the recorder, showing its major components

The temperature recorder is mounted in the upper part of the cabinet; directly below is the amplifier-and-thyratron unit. Mounted on the panel of this unit are the heater-current ammeter, the control switches, and adjustment rheostat. The chassis of the unit is so constructed that it can be withdrawn by means of the handle on the panel to facilitate servicing from the front of the cabinet. The gas chamber and phototube unit are mounted directly on the refrigerator case, and an inspection door is provided in the panel for observing the operation and for servicing. The lower part of the cabinet, where the refrigeration unit is located, is provided with ventilating louvers. Power switches, line fuses, etc., are accessible from the back of the cabinet, through a full-length door.

OPERATION

The operation of the photoelectric system is unaffected by changes in line voltage and their acccompanying changes in light intensity because use is made of two photoelectric tubes connected in opposition. One tube receives a direct beam from the light source; the other receives from the mirror a reflected beam, the intensity of which varies with changes in reflectivity of the mirror when moisture condenses on its surface. The difference between the two beams furnishes the input to the amplifier, which controls the output of the thyratron and, thus, the current in the heater coil, which is connected in series with the anode of the thyratron.

The phototube and optical system are balanced so that with a clear mirror the ammeter indicates the minimum heater current. Then, in operation, as the mirror cools to the dew point and moisture forms on its surface, the automatic photoelectric control increases the heating current sufficiently to hold the mirror at the temperature which will maintain a small dew spot.

REFRIGERATOR UNIT

Referring to FIG. 2, it will be noted that the mirror and heater assembly are mounted directly on the evaporator end face of the low-temperature stage of a two-stage refrigeration unit. This evaporator is mounted in a case which also contains the heat-exchanger coils. A compact arrangement is thus provided for insulating all the low-temperature parts, and heat losses are reduced to the minimum as only the end face of the evaporator is exposed. Both stages are charged with Freon and have a capacity sufficient to cool the mirror to −100 F with no current in the heater coil.

MIRROR-AND-HEATER ASSEMBLY

The mirror-heater assembly comprises a metallic disk with the mirror mounted on its front face and the heater coil on the back. The mirror surface is about ¼ inch in diameter, and the thermocouple is attached at the center and from the rear so that the mirror surface is left smooth for polishing and cleaning.

To insure accuracy in temperature measurement and freedom from possible heat conduction, the thermocouple leads are made of small-size wire (No. 31 B & S gage) and are brought out through a slot in the disk where only small temperature gradients exist. The heater coil is made as thin as is practical, is of the single-layer wafer type, and has a heating capacity ample to raise the temperature of the mirror above ambient against the cooling effect of the refrigeration unit.

By keeping the mass of these components as small as possible, a time constant of 25 seconds is obtainable, which is ample to meet the requirements of industrial processes and for use with temperature-recording instruments.

DEW POINT AND WATER-VAPOR CONTENT

In designing dew-point-measuring equipment there are two general methods of constructing and cooling the mirror. Either the mirror is made so small that no temperature gradients exist across its surface, or the mirror is made larger and then cooled in such a manner as to set up a definite temperature gradient across the surface.

The latter method was selected for the dew-point recorder because it proved to be the best suited to recording exceedingly low temperatures as well as a wide range of dew points under rapidly changing conditions. The light source for the photoelectric viewing system also supplies the required illumination for visual observation, and the clear part of the mirror provides good contrast.

The temperature recorded is that of the thermocouple located at the center of the mirror, which is always the coldest spot during cooling or heating. The temperature gradient then is such that lines of equitemperature form concentric rings, with the outer edge of the mirror two to ten degrees higher than the center. With this system the first appearance of condensate is a spot a the center, and as the temperature drops below th point the spot increases in density and in diamete In this latter case the true dew-point temperature o the mirror is at the outer rim of the spot, adjacent t the clear mirror. It has not proved practical to s position the dew spot with relation to the thermocoupl as to provide a record of this temperature. The tendenc therefore is for the recorder to indicate a temperatur slightly lower than the true dew point. Under norma conditions this effect can be neglected, for when operating at high dew-point temperatures a relatively small size dew spot is used and at low temperatures the temperature gradient becomes negligible.

The data in Table I giving water-vapor content vs dew-point temperature are based upon the vapor pressure over water and, below 32 F, upon supercoole water.(3) This table is recommended for use with th dew-point recorder in preference to the table based o the vapor pressure over ice, as it has been observe that at temperatures as low as −30 F the condensat may exist as minute droplets of supercooled liquid Test data and literature(4)(5)(6) indicate that the formation of condensate on the mirror, whether it appears a ice or as a liquid, is much more closely related to th saturation humidity based upon supercooled water The vapor pressure over ice is less than that over supercooled water(7) and corresponds to a difference in temperature of 9 degrees at −100 F. This means that a these low temperatures, when recording under steady-state conditions (frost spot not increasing or diminishing), the temperature of the center of the mirror i down near the temperature of saturation humidity based on the vapor pressure over water; and, shoulc the temperature gradient be sufficient, the outer-edge temperature of the frost spot could be as high as that corresponding to the vapor pressure over ice at which sublimation occurs.

When working in the frost zone the time lag of the recorder is greater with decreasing than with increasing moisture conditions, as the corresponding rate of sublimation of ice is much less than for the evaporation o liquid or the rate of condensation.

ACCURACY

The accuracy is not materially affected by the rate of gas flow through the chamber. The inlet gas line should be rather small and as short as convenient, to reduce the time required for purging, and should be provided with a filter in case there should be dust ir the gas. Metallic, or some nonhydroscopic, tubing must be used, and if the gas is from a high-temperature source such as an atmosphere-controlled furnace, it must be precooled. In no case, however, should it be cooled to the dew-point temperature, since the mirror must be the coldest surface with which it comes ir contact. Recommended gas flow is from about 1/5 cfm to ¼ cfm.

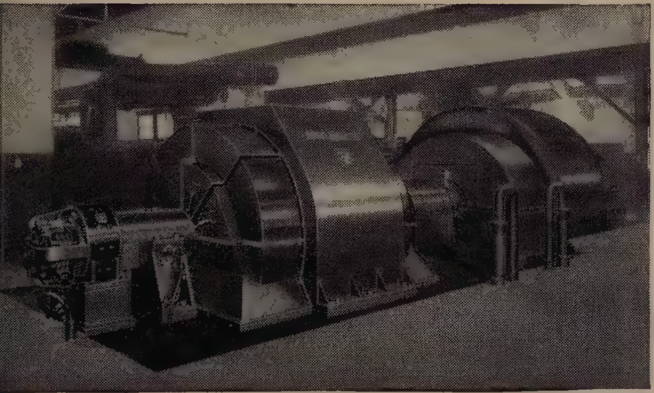
Within the range from ambient to −20 F the accuracy of measurement of the dew-point temperature better than ±2 degrees and, in the range from −20 F own to −90 F, to within ±5 degrees.

UMMARY

The dew-point recorder provides a convenient means f obtaining a continuous indication and record of the noisture content of gases which can be measured by the ew-point method within the range of ambient to −90 F dew point. Alarm contacts on the recorder can e set to operate signaling devices when the maximum ermissible limits for the particular process have been xceeded. For cases in which the gas being measured arries small quantities of extraneous vapors which radually collect on the mirror, a means is provided or periodically clearing the mirror by heating it to a igh temperature for a few seconds once every hour. Ieasurements are usually made at atmospheric presure so that the moisture content can be obtained irectly from the table provided.

REFERENCES

(1) "Dew-point Potentiometer," by S. S. Stack, GENERAL ELECRIC REVIEW, vol. 41, Feb. 1938, p. 106.
(2) Gruses' Method, *Bur. of St. Scient. Paper S-500.*
(3) *Bur. of St. Res. Paper No. 1105.*
(4) A. W. Ewell, *Ref. Eng. 27*, 131 (1934).
(5) Awberry & Griffith, *Prov. Phys. Soc., 47*, 684 (1935).
(6) O. T. Zimmerman and Irving Lavine: *Psychrometric Tables & Charts*, (Ind. Res. Service, Dover, N. H., 1945).
(7) "Determination of Low Humidity," by A. K. Frank, GENERAL LECTRIC REVIEW, vol. 41, Oct. 1938, p. 435.



,000 hp Synchronous Motor, manufactured at C-G-E Peterborough Works, lriving a centrifugal compressor at a large Canadian nickel mine.

In Canada . . .

ten factories manufacture General Electric products. 30 engineering and sales offices and 19 warehouses are located from coast-to-coast to serve you.

CANADIAN GENERAL ELECTRIC CO
LIMITED

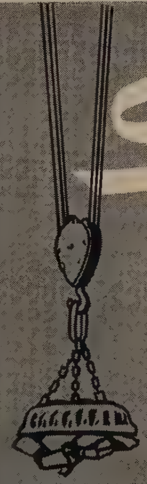
ydney • Halifax • Saint John • Quebec • Chicoutimi • Trois Rivieres • Sherbrooke • Montreal • Ottawa • Toronto amilton • St. Catharines • London • Windsor • Noranda • New Liskeard • Sudbury • Timmins • Fort William Vinnipeg • Brandon • Regina • Saskatoon • Lethbridge • Edmonton • Calgary • Trail • Kelowna • Vancouver • Victoria

It's a **GREENOHM!**

Fixed and adjustable types. 5 to 200 watts standard. Other ratings, terminals, mountings, to order.

★ When you use Greenohms—those distinctive green-colored cement-coated power resistors, it means you are building quality, dependable, long-lasting equipment. For Clarostat Greenohms stand the gaff. The cold-setting cement won't crack, flake, peel. Wire winding is unimpaired in fabrication. The unit withstands heavy overloads without flinching. As rugged mechanically as electrically. A Greenohm lasts and lasts and lasts. ★ Interested in tougher power resistors? Write for Bul. 113.

CLAROSTAT *Controls and Resistors*
CLAROSTAT MFG. CO., INC. DOVER, N. H.



Serving

Since 1880, we have served Industry by purchasing and shipping Scrap to consumer—mills and foundries. Fair dealing is our constant aim.

CONSULT OUR NEAREST OFFICE FOR THE PURCHASE OR SALE OF SCRAP

LURIA BROTHERS & COMPANY, Inc.

Main Office
LINCOLN-LIBERTY BLDG.
PHILADELPHIA 7, PENNSYLVANIA

Yards
LEBANON, PA. • READING, PA.
DETROIT (ECORSE), MICH.
MODENA, PA. • PITTSBURGH, PA.

Branch Offices

BIRMINGHAM, ALA. Empire Bldg.
BOSTON, MASS. Statler Bldg.
BUFFALO, N. Y. Genesee Bldg.
CHICAGO, ILL. 100 W. Monroe St.
CLEVELAND, O. 1022 Midland Bldg.
DETROIT, MICH. 2011 Book Bldg.
HOUSTON, TEXAS Cotton Exchange
LEBANON, PA. Luria Bldg.
NEW YORK, N. Y. Woolworth Bldg.
PITTSBURGH, PA. Oliver Bldg.
PUEBLO, COLO. Colorado Bldg.
READING, PA. Luria Bldg.
ST. LOUIS, MO. 2110 Railway Exchange Bldg.
SAN FRANCISCO, CAL. Pacific Gas & Elec. Co., Bldg.

LEADERS IN IRON AND STEEL SCRAP SINCE 1889

HIGH LIGHTS and SIDE LIGHTS

New Power on the Farm

The number of farms now being served by electric power in the United States has jumped almost 25 percent in the last three years; about 74 percent of the country's 5,750,000 farms now use electricity. Furthermore, the increasing use of ultrasonics, new applications of infrared rays, and the creation of new measuring instruments for research in agricultural engineering are pointing the way to significant developments and more use of electricity on the farm.

One of the most important products now in the developmental stage is the farm crop dryer. It combines a fan, motor, control, and a heat source such as an oil burner, and can be used on such crops as ear corn, small grains, peanuts, cotton seed, rice, hay, and other forages. While not all the problems in its application have been solved, this machine is a definite possibility for future farm use.

The electric calf dehorner sears the tissue at the base of the horn with very little pain for the calf and no danger of infection, the horn dropping off after three or four weeks. A water purifier, using a germicidal lamp in the axis of the machine, is another product now under development.

Milk can be homogenized by ultrasonics, although whether this method can replace present practices is not yet known. The fact that certain frequencies and a certain time element of ultrasonic vibrations can kill harmful bacteria and fungi may lead to future use in the pasteurization of milk. Likewise, ultrasonics have been used successfully to improve seed germinations, and experimentation is going on constantly in that line.

Raindrop Research

The long-standing popular conception of the shape of raindrops has been exploded by recent discoveries made by research scientists. Instead of being symmetrically streamlined, large raindrops can change into a variety of shapes as often as 50 times per second.

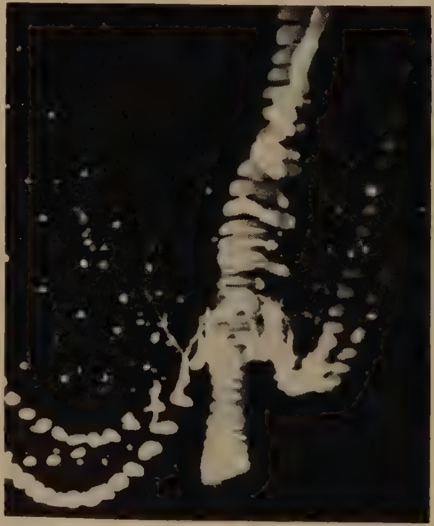
In a special study simulating raindrop behavior, an instrument known as a "drop controller" was developed in which air resistance was produced similar to that encountered by falling raindrops. Reversing the natural order, however, the instrument caused a rush of air to move upward against a drop of water, instead of letting the drop fall against the air.

By regulating the upward air current, a drop of water could be actually suspended for short periods of time, and the same wind-resistance conditions could be produced as occur when raindrops fall. In this manner, water drops were observed visually, and more than 70 stroboscopic pictures were taken of their movements.

Periodic deformations of drops were found to be actually oscillations, in each of which the drop takes a new shape and then returns to its original shape. The oscillations are caused by a combination of the pressures exerted by the surrounding air and the surface tension of the drop.

In larger drops, deformations are more pronounced, sometimes enough so to make a drop resemble a pancake or a flattened sausage. In such cases, the drop may actually rotate as it falls in much the same way as do the blades of a helicopter. A drop about one third of an inch in diameter will oscillate seven times per second; a quarter-inch drop 16 times. At one fifth of an inch in diameter, a drop will oscillate as rapidly as 44 times per second, smaller drops 50 and more times.

Injected into the air stream from a calibrated eye dropper, a water drop remains suspended for a few seconds and can be photographed, in all its positions and shapes, by high-speed stroboscopic flash



A single large water drop undergoing shock breakup in experiments simulating raindrop behavior. The wind stream having been cut off, the drop has begun to fall. But as the air stream is suddenly resumed at lower part of picture, the drop flattens out and breaks up into some 30 small drops. An "offspring" drop, lower left, undergoes typical split

Raindrops which eventually break up apparently progress through various shapes or stages of deformation until they assume a shape similar to that of a telephone receiver, with a narrow neck separating two bulging ends.

In 89 percent of tests made on such drops, they took this shape and then broke at the neck, the bulging ends becoming separate drops and the neck transforming itself into a single small drop. In other tests, the drops exploded or shattered of their own accord, or they split into three equal-size drops plus one or two smaller ones originating from the narrow neck.

Diffraction Instrument Aids Search for Better Materials

An instrument which uses a stream of electrons to study a layer of metal less than a quarter-millionth of an inch thick is aiding engineers of the National Advisory Committee for Aeronautics in their search for better metals and lubricants for jet engines. The electron diffraction instrument is used in determining the effects of various lubricants and in friction studies of polished-metal engine parts. Ordinary lubricants are not adaptable to the high speeds and temperatures inherent in jet-engine operation, and new lubricants, therefore, must be developed.

With the instrument, engineers can detect in a few seconds natural films which emanate from the steel itself and chemical changes produced on the surfaces by lubricants. These chemical changes are not visible under a microscope, and formerly could not be detected with such equipment.

By subjecting the metal parts to temperatures and speeds which simulate actual flight conditions, and then examining the parts with the instrument, researchers have been able to identify specific film materials normally deposited on the bearings when the engine operates. Used to study parts which have been worn by tests, the device helps to discover and minimize the causes of friction.

Electron diffraction instruments are also used to study corrosion, surface deposits, paint pigments, inks, and dyes.

In operation of the instrument, electrons re "boiled off" a white-hot tungsten filaient and focused into a beam by a magetic "lens." For one type of work, the eam then is passed through a twoiillionths-inch-thick section of metal and roduces an image on a fluorescent screen r a piece of ordinary photographic film.

In other applications of the instrument, ie beam is directed to a metal surface at n angle. Tiny projections on the surface iffract the electrons and form the image.

The image produced is different for each iaterial, and both the surface conditions nd crystal arrangement of the molecules f metal can readily be determined.

Electron diffraction instrument in operation. A stream of electrons from this instrument is used to study a layer of metal less than a quarter-millionth of an inch thick

Powdered-metal Coating

Metals shortly may be "taking a powler"—in the literal sense of the word.

Scientists have developed a new method f coating one metal with another, in vhich a layer of metal powder is applied n the surface to be coated.

The surface and coating are then heated or a few minutes to a degree just below he melting point of the two metals, and inally cold-rolled several times. The heatng takes place in an atmosphere of pure iydrogen, so that the powder cannot xidize. Neither the metal nor the metal owder actually melts.

Between cold-rollings, the surface is aniealed. Thickness of the surface is conrolled by depth of the powder layer used.

The technique has yet to be used comiercially, but it has been tried with uccess on sheets of iron and stainless steel. The process is reported to be quite simple vhere small parts are involved, but the uestion of economics cannot be answered vithout some trials on a larger scale. Possible applications are numerous, inluding the manufacture of electrical ontacts and bimetallic elements.

Warm-air Blanket

A notable step in reducing home-buildig costs and increasing heating efficiency a new heating method which blankets ie outer walls of a room with warm air.

The new method of warm-air heat disribution, known as Air-Wall Heating, vas displayed for the first time to the eneral public at the National Association f Home Builders exposition in Chicago. everal test installations have been made newly constructed homes.

Special registers and grilles of the sysem direct the forced warm air upward in fanlike pattern in front of the wall, yet everal inches from the front of the grille o movement of air can be detected.

Since cold walls attract heat from the ody and can cause a chilly feeling even a heated room, the blanket of warm r, by warming the wall, gives the sensaon of radiant heat, and good circulation air within the room reduces the tendncy of warm air to cling to the ceiling.

Approximately 30 percent less air is circulated in the new system in comparison with customary warm-air systems.

It is estimated that two men can install the prefabricated ducts—standard four-inch stovepipe—in the average six-room house in one day, a considerable saving in installation costs. Furthermore, use of adjustable elbows eliminates the hand tailoring now necessary where rectangular ducts are used. The standard pipes and elbows, plus factory-built register boxes and grilles, constitute a "package heating system" that is sent as a unit to the home.

New Air-Wall register is fitted to the register box on a replica of a typical home installation

Low-temperature Research

Temperatures of −459 F will be commonplace in a new low-temperature laboratory—part of the new General Electric Research Laboratory now nearing completion at The Knolls, near Schenectady (N.Y.)—which will be devoted entirely to research at temperatures close to absolute zero. This research is part of continuing work which seeks to find out more about the behavior of matter at low temperatures and the distinctive characteristics which appear as a result of slowed-down molecular action. Such knowledge in turn may give insight into the behavior of matter at all temperatures.

The building, 60 by 70 feet over-all, is equipped to cover the range from room temperature to within one degree of absolute zero, and before long is expected to be able to come within one-tenth of a degree of absolute zero if experiments so require. Half of the space is taken up by two huge liquefying plants, which are expected to produce liquid helium and hydrogen, for use in experiments, at the rate of about seven gallons of liquid hydrogen and two gallons of liquid helium in an hour. The remainder of the building is given over to laboratories for experiments, suitable electric generators to run electromagnets for magnetic studies at low temperatures, and a machine shop for maintenance work on the liquefiers.

Liquid helium and hydrogen will be produced for their extremely low liquefaction temperatures, 4.2 and 20.3 C, respectively, above absolute zero. The liquefiers make use of the so-called "regenerative Joule-Thompson cycle": the gases are compressed, then fed through coils to cool, passed through a chamber cooled by liquid nitrogen (for hydrogen) or liquid hydrogen (for helium), then expanded violently by being sprayed from a nozzle. Only about 20 percent of the gases liquefy at the nozzle, the remainder being used to cool down gases on their way to the nozzle.

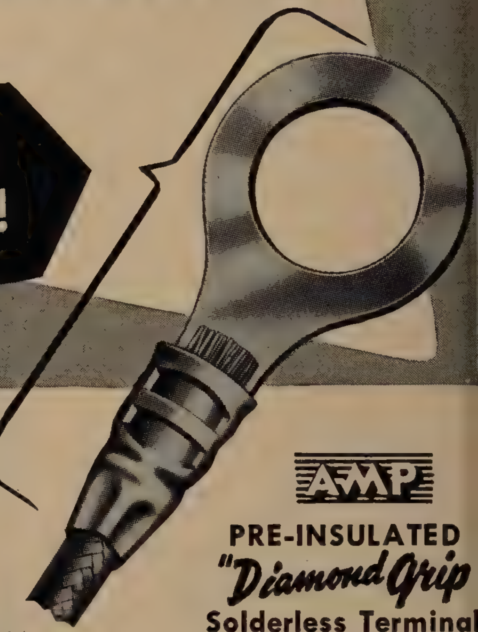
The extremely cold liquids are kept in vacuum-insulated tanks, and the entire liquefier circuits are enclosed in vacuum-insulated jackets. The hydrogen liquefier will operate at a pressure of 2400 psi, and the helium liquefier at 400 psi.

The laboratory is especially designed to provide maximum safety in work with hydrogen, which is explosive when mixed with certain other gases. Heavy shields separate personnel from the liquefying machinery and stored hydrogen. The building's outer walls are made up largely of windows, which would relieve any pressures in the remote event of an explosion.

A-MP

CORROSION-PROOFED *Solderless* TERMINALS

Protect electrical connections against CORROSION!



Hydrogen Sulfide, Sulphur Dioxide, Ammonia, Butane, Hydrochloric and Sulphuric Acid fumes have no measurable effect on AMP Corrosion-Proofed Terminals. Where precision of operation must be maintained under corrosive conditions the AMP Corrosion Proofing Method has proven itself.

AMP corrosion proofing prevents indefinitely any measurable increase of resistance of the terminal due to corrosion.

AMP corrosion proofing actually increases the electrical conductivity of the connection.

AMP corrosion proofing is self-healing, for it re-forms over any break or abrasion.

AMP corrosion proofing has creeping properties which cover any exposed portion of the wire making a continuous metallic joint without interface, thereby assuring a continuous corrosion resistance for the entire connection.

AMP corrosion proofing can be applied to any AMP copper terminal. Thus the PRE-INSULATED or uninsulated terminal installation can be AMP corrosion proofed.

A-MP

PRE-INSULATED
"Diamond Grip"
Solderless Terminal

Precision of operation requires uniformity of terminations. AMP meets this requirement with the Certi-Crimp hand tool. A special ratchet device does not permit the tool to open once the crimping operation is started until that operation is complete — no chance for error — the human element of chance and fatigue is eliminated.

All items covered by Pats. or Pats. Pending

AMP Solderless Terminals
+ AMP Corrosion Proofing
+ AMP Tooling = **"Precision Engineering Applied to the End of a Wire"**

A-MP

AIRCRAFT-MARINE PRODUCTS Inc.
1312 NORTH FOURTH STREET, HARRISBURG, PENNA.
Sole Canadian Representative: F. Manley & Sons, Ltd., Toronto
Offices in New York, Chicago and other leading cities throughout the United States.

NEW PRODUCTS: AND WHAT THEIR MAKERS HAVE TO SAY ABOUT THEM

Piezoelectric Gages

A commercial piezoelectric gage for
easuring transient pressures of instanta-
eous or explosive nature, varying from a few
ounds to 30,000 psi. The gage works on
he principle that when certain types of
rystals are placed under sudden compres-
ive stress, an electric charge is generated
vhich is proportional to the stress. This
harge can be measured and the stress com-
uted or indicated by suitable instrumenta-
ion. The usefulness of these gages lies in
heir ability to measure shocks of high
nagnitude when transmitted through liq-
ids, gases, and occasionally through
olids. They may also be used for such ap-
lications as measuring the explosive forces
n the firing chambers of big guns and in the
ylinders of internal combustion engines.—
*ambridge Thermionic Corp., 462 Concord
ve., Cambridge 38, Mass.*

Demand Registers

A new line of demand registers for use by
lectric utilities in industrial plants and com-
nercial establishments having compara-
ively small loads. These registers, with
implified construction, are available in two
ypes: M-30—indicating; and M-31—cumu-
ative. The latter type has, in addition to an
ndicating dial, a set of four dials for ac-
umulating the demand in kilowatt hours
rom one reading period to another. A
Geneva mechanism in both types for the
nterval resetting operation enables the
iming motor to reset the pointer pusher by
irect-drive gearing without shock.—*Gen-
ral Electric Co., Meter and Instrument
Divisions, West Lynn, Mass.*

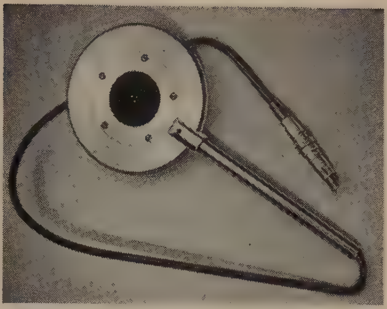
Conductor Cord Trolleys

The Budgit conductor cord trolley is a
evice that makes practical the supplying of
lectric current to electric hoists and other
nobile equipment operating on monorail
racks by a flexible conductor cord. The
onductor cord is supported by the trolleys
n the same track on which the hoist is in-
talled, with both cord and hoist going
hrough the same switches.

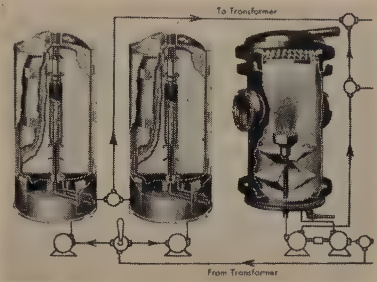
It is practical to use this method of supply
urrent to hoists for tracks as long as ap-
roximately 175 ft in which there are curves
nd switches. This method keeps the con-
uctor cord out of the way with a drop
vhen looped of as little as two feet.—*Man-
ing, Maxwell & Moore, Inc., Muskegon,
Mich.*

Motor Starter

A new magnetic motor starter and mag-
etic contactor designed to give maximum
rotection to alternating-current motors up
o 50 hp, 440 volts. Two outstanding fea-
ures are the relay heaters and the plastic-
ncased coil. The bimetallic relay heaters
vill accurately follow the heating curve of
he motor and the relay adjusts easily for
utomatic or manual reset when a simple
ever is moved. The plastic-encased coil is
ntended to give greater life to the windings
y protecting them from moisture, corro-
ion, and abrasion. It has a permanent self-
ubricating composition impregnated into
he plastic that will keep the magnet guides
liding smoothly and at the same time
liminates annoying low-voltage chatter.—
*he Trumbull Electric Manufacturing Co.,
Plainville, Conn.*

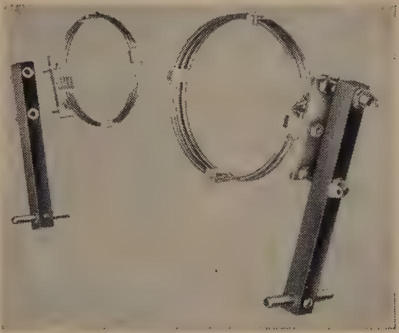


Piezoelectric Gages

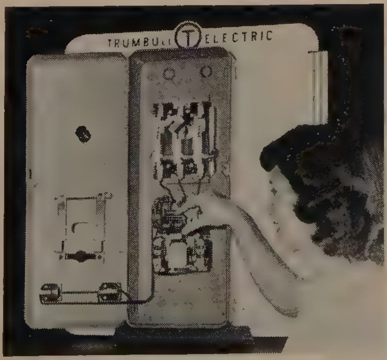


Purifying System

Demand Registers



Plug-in Links



Motor Starter

Field-strength Meter

A new field-strength meter, Model FSM-1, with a 13-channel selector, designed to facilitate and improve television installations. The meter measures actual picture-signal strength, permits actual picture-signal measurements without the use of a complete television set, and measures loss or gain of various antenna and lead-in combinations. Antenna orientation can be done exactly, and amplitudes of interfering signals can be checked. Each unit is individually calibrated.—*Transvision, Inc., New Rochelle, N. Y.*

Purifying System

The Purivac unit is a complete system for purifying, dehydrating, and degasifying insulating oil either in the field or at a central-station location. It comprises dual Cranite purifiers, pumps, and motors; a vacuum dehydration and degasification unit with high- and low-pressure pumps, central operation panel board for all controls; and interconnecting piping, valves, and accessories all mounted and conveniently arranged on a floor truck or skid for portable use. The unit is designed for two-stage operation: (1) purification of the oil to remove oxidation products and foreign contaminants; and (2) dehydrating and degasifying the purified oil to provide for complete removal of moisture and entrained air as may be required. By using two purifiers with a separate pump and motor, operating either singly or in parallel, adequate flow can be obtained to assure a minimum conditioning time.—*Honan-Crane Corp., 949 Sixth St., Lebanon, Ind.*

Plug-in Links

New plug-in links, Type 3550 and 3750, now make possible the matching of standard tank coils to a wide variety of impedances. On present swinging-link assemblies, it is only necessary to replace the swinging-link arm with a new one into which the link coils are plugged. This is easily accomplished by removing the pin that forms the arm hinge and inserting the new arm. Plug-in links now available are made in 1- 3- 6- and 10-turns.—*Barker & Williamson, Inc., 237 Fairfield Avenue, Upper Darby, Pa.*

Wide-range Power Supply

A new wide-range power-supply apparatus has a continuously variable voltage output from 500 to 50,000 volts with a maximum current output of 1 milliampere. Designed for laboratory applications where a variable voltage at low current is required, the power supply can be used in electron diffraction studies; mass spectroscopy studies; and research on high-intensity screens for cathode-ray studies, electron microscopy, and projection television experiments.

High voltage is attained through the use of a radio-frequency oscillator, power amplifier, RF transformer, and a ladder-type voltage tripler circuit. Use of the RF source, about 40 kc, makes possible reduction of the output ripple to a low value by simple filtering means. The wide-range power supply has been designed with exceptional stability as to output voltage, ripple, and load regulation.—*General Electric Co., Special Products Division, Schenectady 5, N. Y.*

(Concluded on next right-hand page)

How Tough Can a High Conductivity Casting Be?

MALLORY 3* METAL

Can Give You The Answer!

When you need *outstanding* physical properties in a casting for high conductivity applications, *Mallory 3 is your answer.* Special heat treatment gives Mallory 3 physical properties superior to those normally encountered in cast brasses and bronzes for high conductivity applications.

Mallory 3 is one of a series of special alloys developed by Mallory to meet industry's demand for materials with special physical properties, and it is available in cast form. Mallory engineers will advise you on your particular problem. Just let us know the physical requirements of your application.

Special Metallurgical Products

P.R. MALLORY & CO., Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

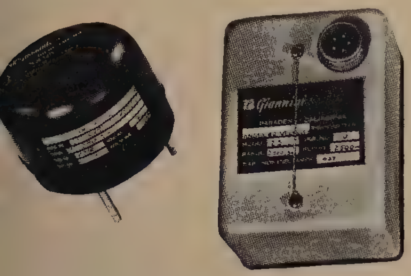
SERVING INDUSTRY WITH

Capacitors
Contacts
Controls
Rectifiers
Switches
Vibrators
Power Supplies
Resistance Welding Materials

*Reg. U. S. Pat. Off.

Rate and Position Gyros

Telemetering rate gyros calibrated for otational measurements from 10 to 1000 eg per sec and position gyros with one- nd two-axis electrical sensory elements. yro accuracies of better than ± 2 percent re offered and production gyros have been



tandardized with 2000-, 2500-, and 5000- hm resistance pick-offs. Other resistance anges furnished on request. Telemetering ate gyros offer natural frequencies to 40 ps and are available damped or undamped. -*G. M. Giannini & Co., Inc., 254 West* *olorado St., Pasadena 1, Calif.*

Electrode Holder

A new leak-proof water-cooled resistance- elding electrode holder, marketed under he name KO Holders. Among the major nprovements achieved in the design is the limination of the problem of drops of ater which cause rust or discoloration of he material being processed. This result is ccomplished by the use of standard size)-rings instead of ordinary packing.

Copper alloy, brass, or stainless steel is sed for the complete assembly, including ll internal parts. This insures full water ow for the life of the unit and keeps the ip-ejector mechanism free from any rust r corrosion which might interfere with its asy, efficient action.—*P. R. Mallory & Co.,* *nc., 3029 E. Washington St., Indianapolis* *, Ind.*

Drill Bit

The RCD rotary drill bit for drilling in oncrete without dulling the bit. These drill its range in sizes from ¼ to 2 in. Bits are

quipped with special heat-treated carbide utters set in and brazed to the blunt end f the bit shaft. The blunt-end design of he bits enables them to drill right through ravel or rounded rocks in concrete rather han being deflected around them. The de- gn also reduces breakage to a minimum.— *otary Concrete Drill Co., 650 S. Arroyo* *arkway, Pasadena 2, Calif.*

High-resistance Alloy

A new alloy, known as Karma, has high electrical resistivity and the ability to retain stable resistance values over wide ranges of temperature. Especially suitable for high-accuracy wire-wound resistors, the specific resistance of this alloy is exceptionally good—at 20 C, it is 800 ohms per circular mil foot. Such high-ohmage material makes possible small resistors—with resultant desirable savings in space and weight.

In the making of potentiometers and resistance units used in radio, radar, and other electrical equipment, a limiting minimum size is specified by some users, due to the lack of mechanical strength. Because of the new alloy's higher specific resistance, it is possible to use a larger diameter of wire for the same resistance per foot.—*Driver-Harris Company, Harrison, N. J.*

Smoke-density Indicator

A new smoke-density indicator and control, designed to indicate industrial smoke-density levels and thus facilitate compliance with smoke-abatement ordinances. The equipment can also be used to control over-the-fire heated air to the fire-box to reduce excessive smoke and thereby improve fuel consumption and boiler efficiency. It consists of a light source, a phototube holder, and an enclosure containing the required control and incorporating an indicator calibrated in Ringlemann units, all in one packaged unit. If desired, a recorder, either of the continuous-strip-chart type or the circular "step" type, can be furnished. The watertight phototube holder is easily mounted on ductwork or on a stack, indoors or outdoors. The complete equipment has only a few interconnecting wires, and is easy to install and maintain.—*General Electric Co., Control Divisions, Schenectady 5, N. Y.*

Bushings

A new all Bakelite insulating bushing of increased strength and durability. Rounded edges protect wire insulation during pulling and when in service, thus guarding against grounds and shorts. Clean, deep threads and the ribbed outer surface facilitate easy, fast installation. One of the physical characteristics is its bounceability. When dropped, it rebounds like a ball, and does not crack, even on concrete. When desired, the bushings are furnished with caps which keep out plaster and other refuse until installation is completed.—*O.Z. Electrical Manufacturing Co., 262 Bond St., Brooklyn, N. Y.*

the Crayons that tell temperatures
TEMPIL STIK 300°

Tempilstiks°

A simple method of determining safe operating temperatures for:

- **BUS BARS**
- **POWER TUBES**
- **TRANSFORMERS and other electrical equipment.**

also in:

- **MOLDING**
- **CASTING**
- **FORGING**
- **DRAWING**
- **HEAT TREATING**
- **WELDING**
- **FLAME-CUTTING, etc.**

Also available in pellet and liquid form

It's this simple: Select the Tempilstik° for the working temperature you want. Mark your workpiece with it. When the Tempilstik° mark melts, the specified temperature has been reached.

$2 each

gives up to 2000 readings

Available in these temperatures (°F)			
125	275	500	1100
138	288	550	1150
150	300	600	1200
163	313	650	1250
175	325	700	1300
188	338	750	1350
200	350	800	1400
213	363	850	1450
225	375	900	1500
238	388	950	1550
250	400	1000	1600
263	450	1050	

FREE—While we cannot supply free Tempilstiks°, we will be glad to send you sample Pellets or sample Tempilaq° *(liquid form)* for trial under your actual working conditions. Be sure to state the temperature of interest to you.

Tempil° corp.
134 WEST 22nd STREET
New York 11, N. Y.

TRADE LITERATURE

Capacitors—Pertinent data on pole-type capacitors is presented, together with detail drawings of both capacitors and mounting brackets, and a cut-out illustration showing the construction details. Catalog No. 145 PF. Six pages.—*Cornell-Dubilier Electric Corp., Power Factor Div., South Plainfield, New Jersey.*

Conveyor—The various applications of the Houdaille conveyor are mentioned, and one typical installation is fully described and illustrated. Perforated catalog sheet. Four pages.—*Honan-Crane Corp., Lebanon, Ind.*

Cutting Tools—A booklet, offered free to metal-working companies, describing proper cutting tools, feed, speed, and estimated time for each boring operation. Titled "Jig Borer Cutting Tools." Twenty pages.—*Moore Special Tool Co., Inc., Bridgeport, Conn.*

Drills—A specification sheet and price list of Steelset diamond-impregnated drills, including core, twist, and disintegrating-core types, as well as reamers and coolant feed for wet drilling. Bulletin DT-330. Two pages.—*Fish-Schurman Corp., 230 E. 45 St., New York 17, N. Y.*

High Vacuum—Current information on developments in the field of high vacuum is given which includes such items as measurement in low pressures and how the glass blowers' art produces intricate high-vacuum pumps. Titled "Current Data on High-vacuum Apparatus." Eight pages.—*Distillation Products, Inc., 755 Ridge Road West, Rochester 13, New York.*

Instrument Transformers—The illustrated 1949 Buyer's Guide contains data on 107 types of instrument transformers, including potential, current, and portable types. Prices, ratings, and ASA accuracy classifications are listed, together with tables giving mechanical and thermal limits of current transformers. GEA-4626-B. Eight pages.—*General Electric Co., Meter & Instrument Divs., West Lynn, Mass.*

Material Handling—In this catalog the descriptive text and numerous illustrations cover all types of overhead handling equipment including cranes—motorized and hand-operated—jibs, monorails, and essential accessories. Twelve pages.—*Abell-Howe Co., 53 W. Jackson Blvd., Chicago 4, Ill.*

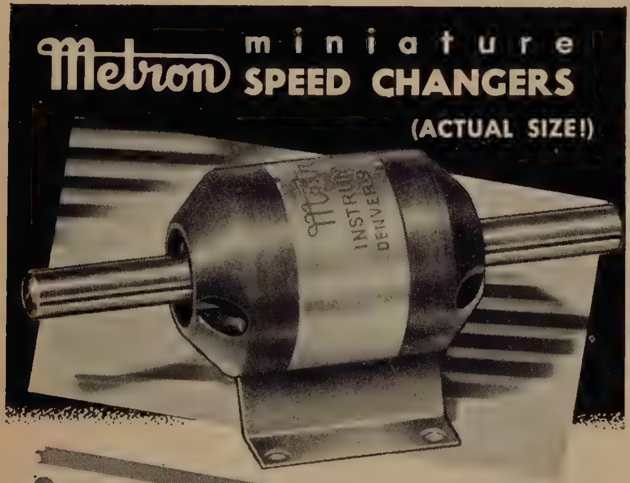
Precision Lathes—A complete line of precision quick-change-gear and toolroom lathes, shown in full color, is described in a new general catalog. Lathe data, specifications, major attachments, and accessories are included. Bulletin No. 100-G. Sixty-four pages. Another new catalog on machine-tool attachments and accessories contains illustrations and specifications of items that make possible the performance of a wider range of work on lathes and drill presses. Catalog No. 77-U. Twenty-eight pages.—*South Bend Lathe Works, South Bend 22, Indiana.*

Silicone Rubber—The fundamentals of silicone chemistry and the performance of the rubber under varied conditions is outlined, together with an analysis of the heat-resistant, mechanical, electrical, and chemical-resistant properties of silicone rubber. Bulletin No. CDP-584. Twenty-four pages. —*General Electric Company, Chemical Dept., Pittsfield, Mass.*

Soldering Tool—A new light-duty 450-watt Therma-Grip soldering tool is described together with other types of soldering sets and their attachments. Perforated Catalog Section C-1. Four pages.—*Ideal Industries, Inc., Sycamore, Ill.*

Strip- and Sheet-feeding Tables—The use of hydraulic elevating tables for transporting and leveling strips and sheets to proper working height. Includes installation photographs and specifications of various models in capacities of 2000 to 10,000 lb. Bulletin 261. Six pages.—*Lyon-Raymond Corp., 7130 Madison St., Greene, N. Y.*

Welding Tools and Fittings—A presentation of the complete line of Tweco products, including electrode holders, ground clamps, cable and terminal connectors, cable splicers, etc. Also gives the new six-bracket quantity price schedule. Twecolog No. 7. Twelve pages.—*Tweco Products Co., P.O. Box 666, Wichita 1, Kansas.*



Metron miniature SPEED CHANGERS
(ACTUAL SIZE!)

- COMPLETE
- STANDARDIZED
- ADAPTABLE
- PRECISION-BUILT FOR QUALITY PRODUCTS

BULLETIN NO. 100 Contains Details. Write for it!

OVER 500 DIFFERENT STANDARD RATIOS!

- Only 1.050" diameter; overall lengths from 3 3/16" to 4 13/16"!
- Ratios from 10:9 to 3,375:1 *standard!* Higher ratios available promptly.
- Transmit power *either way* up to 100:1 ratios!
- Concentric, ball-bearing input and output shafts; hardened steel spur gears; permanent lubrication.
- SPEEDS up to 20,000 RPM on output shaft.
- TORQUES to 2 lb.-in. on low speed shaft.

METRON INSTRUMENT COMPANY
448 Lincoln Street • Denver 9, Colorado

BUILT BY Metron MAKERS OF INSTRUMENTS FOR PRECISION MEASUREMENT

ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

British Thomson-Houston Co. Ltd.

Edison Swan Electric Co. Ltd.

Ferguson, Pailin Limited

Harcourts Limited

Hotpoint Electric Appliance Co. Ltd.
(Incorporating International Refrigerator Co. Ltd. and Premier Electric Heaters Ltd.)

Metropolitan-Vickers Electrical Co. Ltd.

Metropolitan-Vickers-G R S Ltd.

•

Agents and Licensees of the
GENERAL ELECTRIC Co., U.S.A.
for the United Kingdom.

BILLIONTH

SPRAGUE CAPACITOR

Early this year the one-billionth Sprague Capacitor rolled off the fast-moving production lines in North Adams.

Fittingly enough, this billionth unit was one of the revolutionary new molded paper tubulars. Throughout the years, it has been engineering progress as typified by this development that has enabled Sprague to attain its present position as one of the largest, most diversified and most dependable sources of capacitor supply.

Other important developments which have helped materially in swelling the total of Sprague production include *Vitamin Q capacitors for higher voltages, higher temperatures and higher insulation resistance; *Hypass 3-terminal networks; glass-to-metal sealed capacitors; molded *Prokar capacitors for sub-miniature assemblies; high-voltage coupling capacitors; electrolytics for dependable operation up to 450 volts at 85°C., and many other types of capacitors.

*T. M. Reg. U. S. Pat. Off

SPRAGUE

Pioneers of Electric and Electronic Progress

SPRAGUE ELECTRIC COMPANY • North Adams, Mass.

Simple as ABC

Handle heavy reels easily and safely; remove wire or cable from top or bottom, front or back of reel with

ROLL-A-REEL

Style A:
2,000 lbs. cap.
37.50

Style B:
4,000 lbs. cap.
75.00

F.O.B. Cincinnati

Low slanted front and positive front lock insure quick loading or unloading.

Eliminate jacks, cumbersome handling.

Carried easily to reels, job or storage.

Sold through wholesalers only.

WRITE TODAY FOR DETAILS

ROLL-A-REEL
327 WEST FOURTH STREET
CINCINNATI 2 OHIO

JET ENGINES

Giannini ducted pulse jet engines, currently in production, provide reliable operation at high thrust per unit frontal area. Nominal engine diameters are from 6 to 25 inches.

Recently expanded manufacturing facilities afford firm delivery of 1949 improved instrument and powerplant equipment.

Latest Technical Catalogs on Request

G. M. Giannini & Co Inc
285 W. Colorado, Pasadena 1, California
697 Morris Turnpike, Springfield, N. J.

BOOK REVIEWS

(Available books may be purchased through the GENERAL ELECTRIC REVIEW for domestic delivery; none sent on approval.)

ALTERNATING-CURRENT CIRCUIT THEORY

Myril B. Reed—Harper & Brothers, New York. 1948. 619 pp. $5.50.

With the large number of texts available on a-c circuit theory, a new book on this subject, to be worthwhile, must offer something in the way of additional material, a fresh point of view, or both. Professor Reed has succeeded in both these phases, and his new book should take its place among the better texts on the subject.

In addition to the standard treatment of current, voltage, power, and energy relationships in circuit elements, and combinations of circuit elements under steady-state and transient conditions, there is included near the end of the first section of the book an excellent chapter on the writing of circuit equations. The second section, comprising the last five chapters, applies the fundamental concepts of the first ten. Two chapters on three-phase circuits are followed by one each on symmetrical components, steady-state transmission-line theory, and electric filters. The treatment of symmetrical-component theory by the methods of tensor analysis, long advocated by Kron, is a welcome addition in a book of this type.

On the debit side might be mentioned some of the vector diagrams in Chapter 11 which, instead of simplifying the mathematical treatment, appear complicated enough to discourage even the brightest student. In general, however, the treatment is lucid and complete, the nomenclature well-defined, and the examples and problems many and excellent.

F. J. MAGINNISS

COBALT

(A. C. S. Monograph No. 108)

Roland S. Young—Reinhold Publishing Corp., New York. 1948. 189 pp. $5.00.

Another of those useful little books that bring together, in summarized form, published data and knowledge pertaining to one of our important metals. The author is a recognized authority in the field of extraction and refining processes.

Cobalt requires a wider variety of metallurgical operations than do most metals, and its relatively recent strategic importance as an alloying element has stimulated world-wide interest. Twelve well-organized chapters here cover the occurrence of cobalt, its metallurgy, chemical and physical properties, chemical analysis, important alloys, and uses in catalysis, plating, and biological relationships. A well-selected and complete bibliography accompanies each chapter.

The book is recommended for the chemist or metallurgist as a source of general information and a guide to the broad field of knowledge concerning this interesting metal.

W. E. RUDER

ATOMIC ENERGY

Karl K. Darrow—John Wiley & Sons, Inc., New York. 1948. 80 pp. $2.00.

Residents of Evanston (Ill.) were most fortunate in 1947 when Dr. Karl K. Darrow, of the Bell Telephone Laboratories, was selected to give the Norman Wait Harris Lectures at Northwestern University and he chose as his topic Atomic Energy. Few scientists are as skilled as he in making difficult scientific facts clear to the layman. Now that his four lectures are published, substantially in the same words as those he used on the platform, an even large audience will be able to turn for information to this little book for a remarkabl clear account of the basis of a technica achievement that has become an international problem.

After covering in the first lecture th subject of atomic structure, the secon brings him to transmutation of element and the possibility of the conversion of mas into energy. In the third he arrives at th means by which physicists have been abl to induce such transmutations by artificially accelerated particles, the release o energy thereby, and the need of a chain reaction to sustain the process. The clima is reached in Lecture 4, showing how such a chain reaction was achieved and controlled leading to uranium piles, the atomic bomb and the promise of nuclear power.

Simple analogies and apt illustration make his story one that the general reade can easily understand. Since that eventfu day in 1945 when the destruction o Hiroshima was announced, there have bee many books designed to give the layma some notion of what was behind the bomb and what the work meant in possible peacetime uses. This is certainly one of the simplest—and one of the best.

JAMES STOKLE

THE CHEMISTRY OF HIGH POLYMERS

C. E. H. Bawn—Interscience Publishers, Inc., New York. 1948. 259 pp. $4.50.

The author of this monograph has given us a very readable, well-organized account of the fundamental knowledge now available in the field of high polymers. A broad picture is presented of the kinetics of condensation and addition polymerization, with emphasis on the detailed mechanism of these reactions. A good account is given of the thermodynamics of solutions of macromolecules.

The story of size and shape of linear polymers prepares one for an account of the remarkable mechanical properties obtainable with such materials in terms of molecular size, crystallinity, and amorphous character. An account is given of the present state of knowledge of the correlation between molecular structure of the polymer and such physical properties as elasticity, deformability, and hardness.

This reviewer feels that the book is the best which has appeared to date in this general field and heartily recommends it to all workers in the field and also to those who wish to obtain a good scientific account of our present knowledge of high polymers.

A. L. MARSHALL

FUNDAMENTALS OF ELECTRIC WAVES

(Second Edition)

Hugh Hildreth Skilling—John Wiley & Sons, Inc., New York. 1948. 252 pp. $4.00.

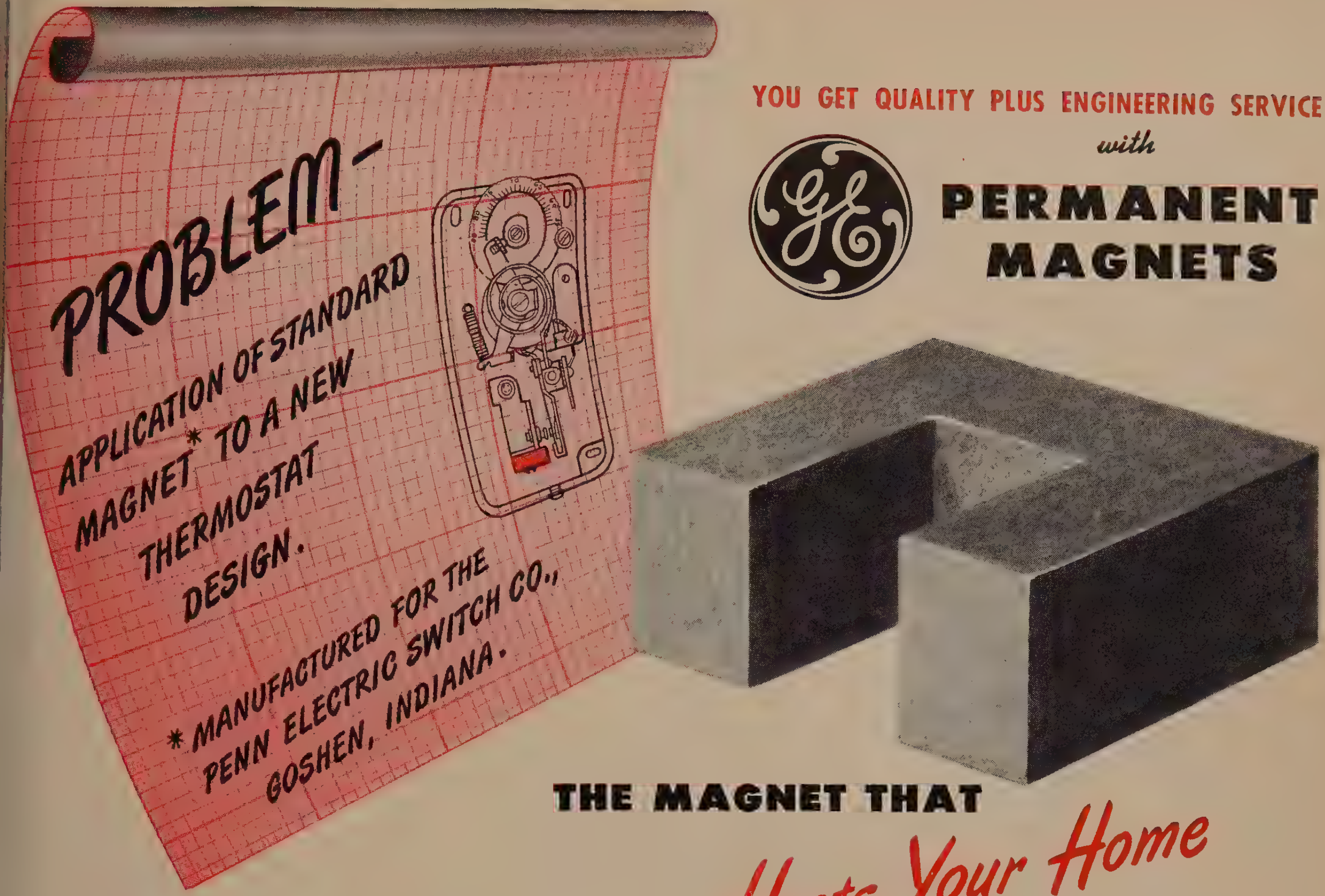
The first edition of this book was received with enthusiasm by students and engineers alike. It has proved to be a most readable and understandable introduction to the study of electric waves.

The second edition should meet with an even greater success; for the material has been rewritten so that the rationalized mks system of units is used throughout, and revisions in the text have been made in the

(Continued on next left-hand page)

YOU GET QUALITY PLUS ENGINEERING SERVICE
with

PERMANENT MAGNETS

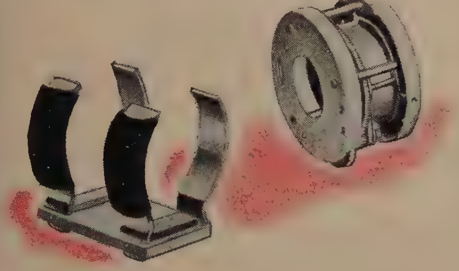

PROBLEM-
APPLICATION OF STANDARD MAGNET* TO A NEW THERMOSTAT DESIGN.
* MANUFACTURED FOR THE PENN ELECTRIC SWITCH CO., GOSHEN, INDIANA.

THE MAGNET THAT *Heats Your Home*

Here's a magnet that's simple in design yet is the heart of Penn room thermostats. . . . thermostats which *anticipate* heat requirements before temperature *changes.* The Sintered Alnico 2 permanent magnet snap-acting contact mechanism responds almost instantly to temperature variations.

This application is an excellent example of cost-saving by using stocked G-E permanent magnets. Since the magnet is stocked there are no special tool charges. And orders for stocked magnets are filled quickly, eliminating costly production slow-downs to you.

Perhaps a standard listed magnet can be used in your applications. And if a standard G-E permanent magnet will not meet your requirements, our engineers will be glad to design one specially for you. Remember, too, that General Electric manufactures all grades of cast and sintered Alnico as well as special magnet alloys.



G-E Permanent Magnet SUB-ASSEMBLIES

Here's a new product which may lower your permanent magnet costs. Permanent magnet component assemblies are specially designed to your specifications—ready for immediate installation in your final product. All permanent magnets are mounted for maximum efficiency. And, assembly and calibration operations are completely eliminated at your plant. For your free copy of General Electric's new bulletin on G-E Permanent Magnet Subassemblies mail the coupon shown below.

CHEMICAL DEPARTMENT, SECTION 18-4
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.

Please send me: ( ) Bulletin, CDM-2A, "G-E PERMANENT MAGNET CATALOG" ( ) Bulletin, CDM-16, "G-E PERMANENT MAGNET SUB-ASSEMBLIES"

Name____________________
Company____________________
Products Mfrd.____________________
Address____________________
City____________________State__________

GENERAL ELECTRIC

CD49-K1

BOOK REVIEWS (Continued)

sections treating antennas, wave reflection, wave guides, and wave propagation so as to cover the fundamentals and introductory analysis in a more thorough manner. The same clear methods of presentation used in the first edition have been preserved.

Mr. Skilling's method is to introduce a series of simple experiments in electrostatics, magnetostatics, and time-varying electric fields and build the experimental phenomena into a unified theory for electric waves, leading to Maxwell's field equations and their application. He develops the subject of vector analysis in a very clear fashion and uses it in the mathematical representation of the theory. Problems are listed as each new topic is covered, the intention being to tie the theory down to practical application; the problems have been expanded in number and scope in the new edition.

Congratulations are due Mr. Skilling for the worthwhile revision of an already commendable book.

K. O. Straney

Spherical Harmonics (Second Edition)

T. M. MacRobert—Dover Publications, Inc., New York. 1948. 387 pp. $4.50.

A revised edition of a work first published about twenty years ago, this book represents an attempt to present the theory of spherical harmonics without resorting to contour integration. About a third of the book is devoted to applications to physical problems.

Mathematical subjects covered are: Fourier series, spherical harmonics, the hypergeometric function, Legendre polynomials, Legendre functions, associated Legendre functions of integral order and of general (real) order, Bessel functions, and asymptotic expansions. Various applications are also treated, such as conduction of heat, vibrations of strings and membranes, potential theory, and electrostatics.

The book should be of interest to those interested in elementary applied mathematics and mathematical physics. A knowledge of calculus is presumed.

Charles Concordia

A Concise History of Mathematics (2 Vols.)

Dirk J. Struik—Dover Publications, Inc., New York. 1948. 317 pp. $1.50 per vol.; $3.00 per set.

Here is presented a highly condensed outline of the development and progress of mathematics from the Old Stone Age to the end of the nineteenth century. It is in two small volumes of about 150 pages each, the split being made at the end of the sixteenth century, and is thus made easy to carry about. A feature of the book is an extensive, but selected and annotated, bibliography following each of the chapters.

The author has made a very readable and interesting book out of what could very well have been merely a dry outline. This has been accomplished by treating only the essential ideas and minimizing references to other developments. Several points are well brought out—the great importance of a proper notation to a fruitful development of mathematics, and the comparative youth of many of the men who have made some of the most significant discoveries. Unfortunately the book is marred by a number of curious and sometimes amusing misprints.

Charles Concordia

Crystal Structures: Section I

Ralph W. G. Wyckoff—Interscience Publishers Inc., New York. 1948. 520 pp. $8.00

This book is in loose-leaf form, so tha new information can be added in the appropriate places as it becomes availabl There are to be, eventually, three mai sections:

Section I, Crystals of the Elements an of Simple Inorganic Substances

Section II, Crystals of Complex Inorgani Substances

Section III, Crystals of Organic Substances.

Of these, only Section I has appeared—i half fills the loose-leaf binder. The autho promises to bring out the other two section in the near future.

Crystal Structures fills the need for compendium of information on the atomi arrangements in crystals. Each type o structure is described clearly and is usuall depicted in one or more excellent drawings Tables are provided listing the substance which belong to each structural type together with their lattice constants an interatomic distances. A complete and up-to-date bibliography is appended. Beside this purely structural information, on finds here and there in the text discussion of such aspects of crystal chemistry an crystal physics as are closely related t crystal structure. For instance, atomi radii are treated at some length as well a some of the structural peculiarities of soli solutions.

It is the opinion of the reviewer, judgin by Section I of this volume, that no on working in any of the fields using physica or chemical data can afford to exclude i from among his reference books.

David Harker

Engineers, designers, buyers — write for ***H-149***

THE NEW 192 PAGE DIALCO HANDBOOK OF PILOT LIGHTS

Complete data on the lamps used in pilot lights.

More than 2,000 Underwriters' Listed Pilot Light Assemblies.

Here is one example designed for NE-51 Neon Lamp

No. 521308-997 (110 or 220 Volts)

Features:
- MULTIVUE CAP — 7 COLORS
- BUILT-IN RESISTOR
- EXTREMELY RUGGED
- VERY LOW CURRENT

Foremost Manufacturer of Pilot Lights

The DIAL LIGHT COMPANY of AMERICA
900 BROADWAY, NEW YORK 3, N. Y.

ELECTRITE

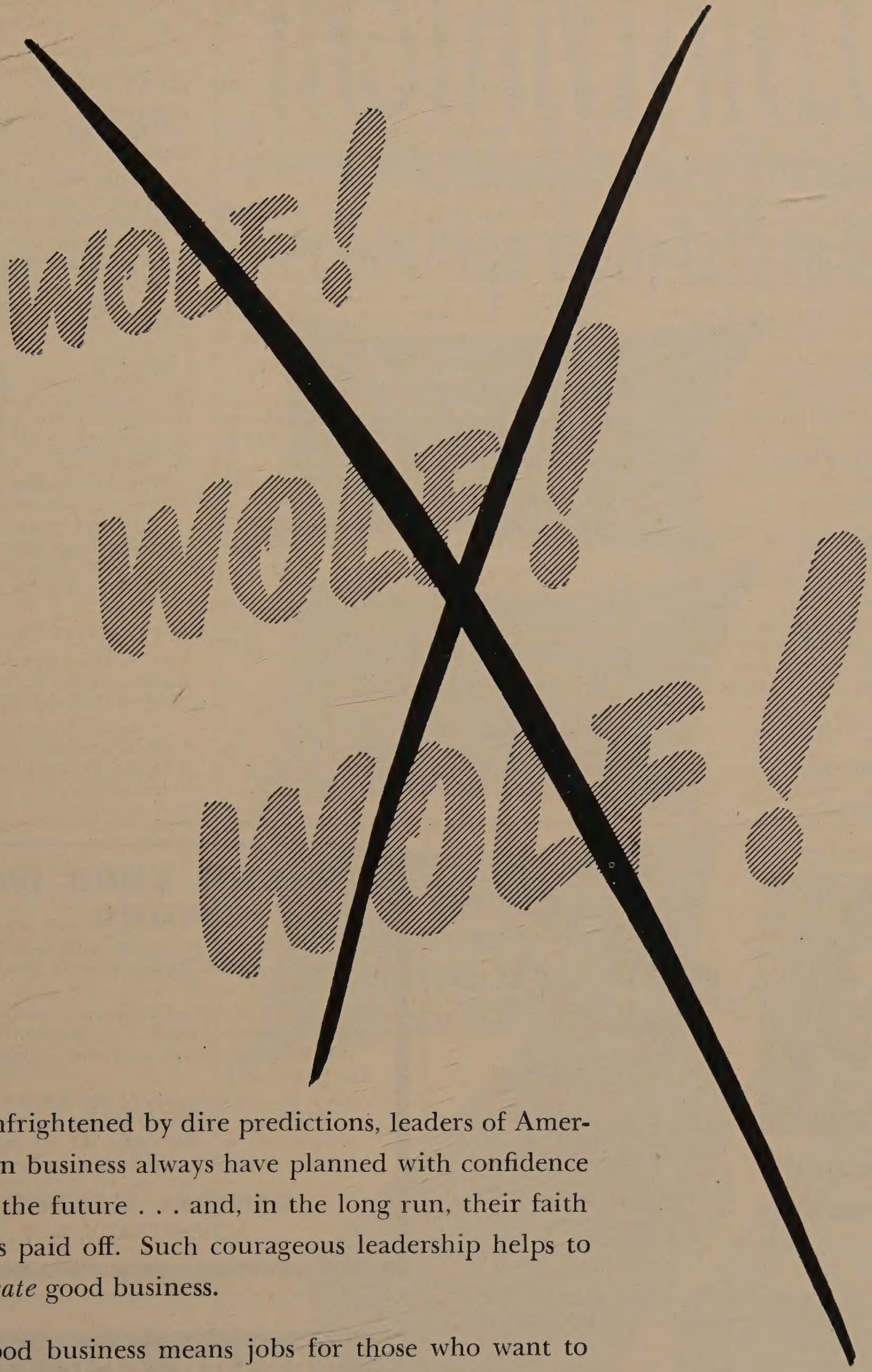
A high grade fibre board for electrical insulation. A material of quality possessing high tensile and dielectric strength. Used by many of the leading manufacturers of electrical equipment.

DENSITE

An extremely hard board of superior quality which can replace the more expensive types of insulating materials.

Pulp Products Department

WEST VIRGINIA PULP & PAPER COMPANY
230 Park Avenue, New York, N.Y. 35 E. Wacker Drive, Chicago, Ill.


WOLF!
WOLF!
WOLF!

Unfrightened by dire predictions, leaders of American business always have planned with confidence in the future . . . and, in the long run, their faith has paid off. Such courageous leadership helps to *create* good business.

Good business means jobs for those who want to work. It's the best defense against the termites who are working to undermine the individual liberties Americans enjoy. 6593

SKF INDUSTRIES, INC. PHILADELPHIA
BALL and ROLLER BEARINGS

LIBRARY NOTES

ON ARTICLES IN OTHER TECHNICAL JOURNALS

AIRPLANES

AIRCRAFT ACCESSORY SYSTEM, by T. B. Holliday. *Prod. Engng.*, Nov. 1948; v. 19, pp. 119-121.

Comparison of hydraulic, pneumatic, and electric solutions to the problems encountered in the design of aircraft accessories; especially those concerned with the weight of equipment and devices needed to produce, distribute, and utilize power.

EXPERIMENTAL VERIFICATION OF THEORY OF LANDING IMPACT, by Walter Ramberg and Albert E. McPherson. *Nat. Bur. Stds. Jour. Res.*, Nov. 1948; v. 41, pp. 509-520.

Drop tests of an idealized wing and alighting gear made to provide an experimental check on methods for computing the transient bending stresses in the wing produced by a symmetrical vertical landing impact.

CORROSION-RESISTING MATERIALS

13TH CHEM & MET REPORT ON MATERIALS OF CONSTRUCTION. *Chem. Engng.*, Nov. 1948; v. 55, pp. 97-128.

A survey of corrosion-resisting materials for use in the production and handling of specific chemicals. Includes a directory of such materials, their manufacturers, and properties.

ELECTRIC DRIVE

ELECTRICAL-DRIVE EQUIPMENT FOR NEW HIGH-SPEED TANDEM MILL, by A. F. Kenyon. *Iron & St. Engr.*, Nov. 1948; v. 25, pp. 49-59.

Describes electric-drive equipment for a cold-reduction tin-plate mill.

ELECTRIC POWER

POWER SYSTEM FOR GENERAL ELECTRIC ELECTRONICS PARK, by H. J. Finison and C. W. Cuno. *Mill & Factory*, Nov. 1948; v. 43, pp. 112-115.

An installation where maximum safety, reliability, flexibility, and ease of maintenance are obtained through the use of standardized apparatus.

FOUNDRY PRACTICE

DYNAFLOW ROTORS CAST IN PLASTER MOLDS, by Chester Ricker. *Am. Mach.*, Nov. 18, 1948; v. 92 pp. 120-123.

How the Antioch process, not to be confused with lost wax, provides a means of making intricate aluminum castings with smooth surfaces held to close tolerances.

ELECTRON OPTICS

AN ION MICROSCOPE WITH A TRANSVERSE MAGNETIC FIELD, by Nobuji Sasaki. *Jour. App. Physics*, Nov. 1948; v. 19, pp. 1050-1053.

A brief discussion of electron and ion microscopes, followed by a description of a low-magnification, electrostatic ion microscope. This instrument is of the emission type wherein the source of positive ions is imaged.

HEAT PUMP

HEAT-PUMP TESTS PROVIDE BASIC DAT ON GROUND-COIL SYSTEM, by Charles H Coogan, Jr. *Elec. Lt. & Pr.*, Nov. 1948 v. 26, pp. 62-67, 106.

Experimental project devoted to de termination of earth-temperature dat and absorption characteristics of burie tubes. These data permit economic stud of the heat-pump method of residentia heating and analysis of the design an operating factors.

IMPACT

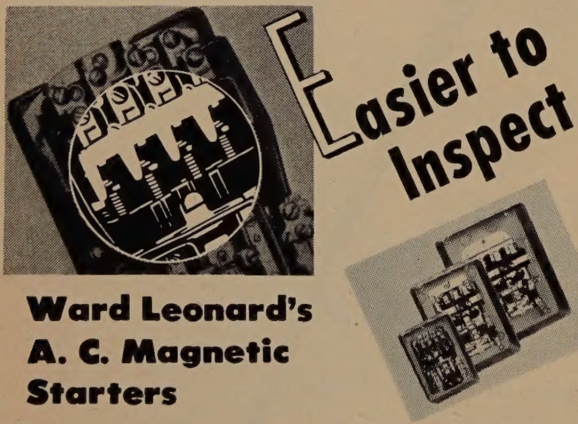
BALL RELEASE MECHANISM TRIGGER SHOCK-TESTING AIR GUN, by John H Armstrong. *Mach. Design*, Nov. 1948; v. 20 pp. 95-99.

How shock-testing air guns are used t simulate field-shock conditions associate with high-velocity impacts, such as o mines launched from aircraft, or wit relatively long-duration accelerations a in the launching of missiles.

LOCOMOTIVES, GAS-TURBINE

THE COAL-BURNING GAS-TURBINE LOCO-MOTIVE, by C. K. Steins. *Ry. Age*, Nov. 27 1948; v. 125, pp. 1020-1022.

A report on the status of the Locomotiv Development Committee project tha indicates completion "is not just aroun the corner."



Ward Leonard's A. C. Magnetic Starters

Ease of inspection is one of the many features of Ward Leonard's sizes 1, 2 and 3 across-the-line non-reversing A.C. magnetic starters.

Removing a single key permits the entire moving contact assembly to be withdrawn for inspection of all main silver contacts, both moving and stationary.

And it's easier to replace main stationary contacts, too, due to the use of individual spring retaining clips.

Write for Bulletin 4110. Ward Leonard Electric Co., 62 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC CO.

Result-Engineered Controls

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

RETURN YOUR 1948 COPIES FOR BINDING and we will prepare them for you in our attractive and durable, standard gold-stamped, black half-morocco leather binding, with cloth sides.

The price is only $6.00 a set (extra postage for return delivery outside the U.S.A., $1.00). We can still replace any missing issues and the annual index for 1948 at $1.00 each.

Also, bound volumes of the Review for the years 1940 to 1948 are available in the above binding at $10.00 an annual volume (plus $1.00 for delivery outside U. S. A.); prices of others on request.

GENERAL ELECTRIC REVIEW
SCHENECTADY, N. Y., U. S. A.

SEXTON CAN COMPANY
Incorporated
Everett Massachusetts
Manufacturers of
Ash Barrels
Kitchen Waste Cans
Underground Garbage Receivers

CAPACITOR CASES
both Fabricated and Deep Drawn
FIVE GALLON
Open and Closed Top Shipping Containers

METAL STAMPINGS
SPECIAL SHEET METAL WORK

MEASURING INSTRUMENTS

Air Proportional Counters, by J. A. Simpson, Jr. *Rev. of Sci. Instr.*, Nov. 1948; v. 19, pp. 733-743.

Some properties of proportional counters using air at atmospheric pressure are described. It is shown that a variety of counter designs may be developed which are stable both with and without thin windows.

The Geiger Discharge, by D. H. Wilkinson. *Phys. Rev.*, Nov. 15, 1948; v. 74, pp. 1417-1429.

Attempts to explain the phenomena associated with development of the positive-ion sheath in Geiger counters.

Quantitative Amplitude Representation in Sound Spectrograms, by W. Koenig and A. E. Ruppel. *Acoustical Soc. of Am. Jour.*, Nov. 1948; v. 20, pp. 787-795.

Several methods are described for recording amplitude variations in measurable steps. These methods include contours, dot spacing, distinctive shadings, and variable area patterns.

Strain Gage for Testing Sheet Metal at High Temperature, by Glen Guarnieri and James Miller. *Metal Prog.*, Nov. 1948; v. 54, pp. 692-694.

An extensometer and instrumental setup that utilizes eight strain gages, so mounted as to cancel out numerous variables and record a single equated value at any instant.

PLASTICS

S-Polymer Films, by R. G. Newberg and others. *Modern Packaging*, Nov. 1948; v. 22, pp. 151-156, 204, 206.

A new transparent packaging material. Laboratory studies indicate superior protection for fresh and dried fruits through the control of moisture- and gas-transmission rates.

POLISHES AND POLISHING

Electropolishing Stainless Steels, by Arthur P. Schulze. *Steel*, Nov. 15, 1948; v. 123, pp. 109, 112, 114, 145-146, 148.

Practical value of electrochemical polishing as a production tool, as currently demonstrated on more than 65 different types of products, parts, and assemblies fabricated from stainless steel.

STRAINS AND STRESSES

X-ray-measuring Strains in Metal. *Steel*, Nov. 29, 1948; v. 123, pp. 79-80, 90.

Apparatus assembled at the National Bureau of Standards, to be used in an effort to correlate progress of fatigue damage with surface-strain measurements.

VOLTAIC CELLS

The Dry Voltaic Pile, by A. Elliott. *Electronic Engng.*, Oct. 1948; v. 20, pp. 317-319.

Description of the Zamboni voltaic pile, developed to supply three thousand volts to operate an infrared image-converter tube.

WELDING

Gas-shielded Metal Arc-welding Process, by Jesse S. Sohn and A. N. Kugler. *Weld. Jour.*, Nov. 1948; v. 27, pp. 913-915.

A new development in which a bare wire arc is shielded by gas. Means are provided for manual and automatic welding.

Materials Joined by New Cold-welding Process, by A. B. Sowter. *Mat. & Methods*, Nov. 1948; v. 28, pp. 60-63.

Strong welds in a number of nonferrous materials, particularly aluminum and copper, are possible with this simple cold-welding method sometimes called "pressure welding."

INSTANTANEOUS

recordings from D.C. to 100 cps!

Accurate recordings of voltages, pressures, strains, vibrations and countless other phenomena.

Permanent ink on paper recordings by Brush Oscillographs make their use almost unlimited.

Either A. C. or D. C. signals can be measured. Whenever desired, recordings may be stopped for notations on chart-paper.

• Investigate Brush measuring devices before you buy . . . they offer more for your money . . Why not have a Brush field engineer call? At no obligation, of course. Just call or write . . today . . you will find it worth a few seconds' time!

THE Brush DEVELOPMENT CO.

3405 Perkins Avenue • Cleveland 14, Ohio, U.S.A.
MAGNETIC RECORDING DIV. • ACOUSTIC PRODUCTS DIV.
INDUSTRIAL INSTRUMENTS DIV. • CRYSTAL DIVISION

Canadian Representatives: A. C. Wickman, (Canada) Ltd., P. O. Box 9, Station N, Toronto 14

THIS IS A LOAF OF BREAD

Not much of a loaf, is it? Wonder why? Well, let's see what went into it.

Flour? Yes, the right amount. Water? That too. Salt? A proper pinch. Milk? The required measure. Well, how come?

No yeast!

So no loaf. Just a flat, hard, unpalatable crust.

Business is like a loaf of bread. Take away the leavening agent, and it falls flat.

The yeast of business is — profits.

A business needs profits to grow on. It needs profits to build new plants, to develop new products. It needs profits to keep men on the job, to open new jobs for more and more wage earners.

When American business is deprived of profits, the American way of life is endangered. Confiscatory taxes deprive business of the yeast it needs to rise to its fullest usefulness . . . to men on the job . . . to management . . . to stockholders . . . to government itself.

Sherron Electronics

SHERRON ELECTRONICS CO.

Division of Sherron Metallic Corporation

1201 FLUSHING AVENUE • BROOKLYN 6, N.Y.

MANUFACTURERS OF ELECTRONIC DEVICES AND SHEET METAL FABRICATION